DOE/RL-95-73
Rev. 1

Operation and Maintenance Plan for the 300-FF-5 Operable Unit

United States
Department of Energy

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DOE/RL-95-73
Rev. 1

Operation and Maintenance Plan for the 300-FF-5 Operable Unit

May 2002

United States Department of Energy

P.O. Box 550, Richland, Washington 99352

EXECUTIVE SUMMARY

This operation and maintenance (O&M) plan describes the integrated monitoring program and administrative tasks that will be used to evaluate the implementation of the selected remedy for groundwater contamination in the 300-FF-5 Operable Unit (OU). The approach described in this plan is based on the Record of Decision (ROD) for the 300-FF-1 and 300-FF-5 OUs (EPA 1996) and the *Explanation of Significant Difference for the 300-FF-5 Record of Decision* (ESD) (EPA 2000). The selected remedy for groundwater contamination (as documented in the ROD) is monitored natural attenuation and institutional controls. This document describes the implementation plans for the monitored natural attenuation component of the selected remedy. The Hanford Site-wide institutional control plan (currently being drafted by the U.S. Department of Energy) will describe the institutional controls component of the selected remedy. The areal extent of the 300-FF-5 OU includes any groundwater affected by the 300-FF-1 and 300-FF-2 source sites and burial grounds. In addition to the above activities, this O&M plan will track groundwater contaminant plumes entering the 300 Area from offsite sources (i.e., 1100 and 200 Areas); however, the remedy selection decision does not apply to these contaminant plumes.

The goals of the 300-FF-5 O&M plan are to support the ROD and ESD by the following actions: (1) provide background information, (2) provide a detailed plan of action, (3) establish data analysis and reporting requirements, and (4) determine whether additional groundwater remedial actions are necessary to protect human health and the environment.

The selected remedy for the 300-FF-5 OU is an interim remedial action that, among other actions, involves imposing restrictions on the use of the groundwater until such time as health-based criteria are met for uranium, trichloroethylene, 1,2-dichloroethylene, and tetrachloroethylene. The 300-FF-5 ESD (EPA 2000) further expanded the groundwater plumes subject to this selected remedy to include uranium and tributyl phosphate contamination associated with the

316-4 Crib/618-10 Burial Ground, the tritium plume associated with the 618-11 Burial Ground and other contaminants detected through 300 Area monitoring activities (e.g., strontium-90). The selected interim remedy includes the following:

- Continued monitoring of groundwater that is contaminated above health-based levels to ensure that concentrations continue to decrease
- Verification of numerical model predictions of contamination attenuation in order to evaluate the need for active remedial measures
- Institutional controls to ensure that groundwater use is restricted to prevent unacceptable exposure to groundwater contamination.

Specific O&M plan monitoring objectives include the following:

- Verify that natural attenuation reduces groundwater contamination concentrations to drinking water maximum contaminant levels over a reasonable time period
- Confirm that contaminant concentrations in the river seeps do not exceed ambient water quality criteria or established remediation goals
- Validate contaminant fate and transport conceptual models.

These objectives will be achieved by sampling, analyzing, and evaluating plume- and/or area-specific groundwater monitoring wells and near-shore seep water, as well as river water and biota associated with the river seeps. The time required to reach compliance will be estimated based on an evaluation of the data. The data results will be compiled in annual reports that will provide an interpretation and evaluation of all media being monitored. The annual reports will discuss the effectiveness of source removal (i.e., remove-treat-dispose remedy) on groundwater quality; the impact of residual deep vadose zone contamination on groundwater quality; and whether additional remedial actions, alternative concentration limits, or technical impracticability should be considered if natural attenuation is determined to be ineffective. This O&M plan addresses the following:

- Monitoring 300 Area groundwater to ensure that remediated 300-FF-1 and 300-FF-2 waste sites are not impacting groundwater quality

- Groundwater monitoring for the 316-4 Crib and the 618-10 and 618-11 Burial Grounds

- Shoreline monitoring requirements, including the Columbia River, seeps, and associated biota

- An evaluation of the monitoring needs for groundwater contamination sources identified in the annual Hanford Site groundwater monitoring report that are associated with individual waste sites contained in the 300-FF-1 and 300-FF-2 Ous

- Annual monitoring reporting requirements

- A comprehensive analysis of the natural attenuation remedy for all contaminant plumes in FY 2004.

- The annual reevaluation of the groundwater monitoring program adequacy for the 300-FF-1 and 300-FF-2 OU waste sites and provisions for proposing changes to the O&M plan and/or the sampling and analysis plan for the 300-FF-5 OU, as appropriate. The reevaluation may result in revising the list of analytes monitored at existing wells, adding or deleting monitoring wells, and revising Columbia River seep (and associated biota) monitoring needs. The review may also identify the need for additional groundwater remedial actions (which would be implemented through an amendment to the 300-FF-5 ROD).

The first version of this document (Rev. 0) was developed in 1996. The major changes incorporated into this updated version (Rev. 1) are as follows:

- The scope of groundwater monitoring plan has been expanded to include new areas (the vicinity of the 316-4 crib, 618-10 burial ground, and 618-11 burial ground).
- The number of monitoring wells increased from 17 to 39 to accommodate the new areas and provide better coverage overall.
- The groundwater monitoring frequency was increased from annual to semi-annual (i.e., 2x/year) for many wells.
- Annual Columbia River shoreline, seep, and biota monitoring was added to address potential contaminated groundwater effects on shoreline resources.
- A comprehensive natural attenuation analysis in FY 2004 to support the next *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* 5-year review was added.
- The 300 Area background information, hydrogeology, contaminant plumes, and conceptual model are discussed in greater detail to provide a better basis for the O&M plan.
- The contaminants of concern in revision 0 were cis-1,2-dichloroethene, trichloroethene, and uranium. To address the new areas of concern identified for 300-FF-5, the contaminants of concern in revision 1 have been expanded to include volatile organic analytes (i.e., trichloroethylene, dichloroethylene, and tetrachloroethylene), nitrate, uranium, tritium, and strontium-90.
- References to contractor-specific procedures have been removed.
- An updated data quality objectives process discussion has been added as Appendix A.
- Current and historical plume maps have been added as Appendices B and C.

- Sections of the groundwater monitoring plan for the 300 Area Process Trenches have been added as Appendix D.

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ACRONYMS

ACL	alternative concentration limit
AWQC	ambient water quality criteria
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
COC	contaminant of concern
CVP	cleanup verification package
DOE	U.S. Department of Energy
DOH	Washington State Department of Health
DQO	data quality objective
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ESD	explanation of significant difference
FY	fiscal year
HEIS	Hanford Environmental Information System
ICP	inductively coupled plasma
K_d	distribution coefficient
MCL	maximum contaminant level
MNA	monitored natural attenuation
MTCA	*Model Toxics Control Act*
NPL	National Priorities List
O&M	operations and maintenance
OU	operable unit
PNNL	Pacific Northwest National Laboratory
RAO	remedial action objectives
RCRA	*Resource Conservation and Recovery Act of 1976*
RESRAD	RESidual RADioactivity
RI/FS	remedial investigation/feasibility study
ROD	Record of Decision
SAP	sampling and analysis plan
SESP	Surface Environmental Surveillance Project
STOMP	Surface Transport Over Multiple Phases
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
USGS	U.S. Geological Survey
VOA	volatile organic analyte
WAC	*Washington Administrative Code*

METRIC CONVERSION CHART

Into Metric Units			Out of Metric Units		
If You Know	*Multiply By*	*To Get*	*If You Know*	*Multiply By*	*To Get*
Length			**Length**		
inches	25.4	millimeters	millimeters	0.039	inches
inches	2.54	centimeters	centimeters	0.394	inches
feet	0.305	meters	meters	3.281	feet
yards	0.914	meters	meters	1.094	yards
miles	1.609	kilometers	kilometers	0.621	miles
Area			**Area**		
sq. inches	6.452	sq. centimeters	sq. centimeters	0.155	sq. inches
sq. feet	0.093	sq. meters	sq. meters	10.76	sq. feet
sq. yards	0.0836	sq. meters	sq. meters	1.196	sq. yards
sq. miles	2.6	sq. kilometers	sq. kilometers	0.4	sq. miles
acres	0.405	hectares	hectares	2.47	acres
Mass (weight)			**Mass (weight)**		
ounces	28.35	grams	grams	0.035	ounces
pounds	0.454	kilograms	kilograms	2.205	pounds
ton	0.907	metric ton	metric ton	1.102	ton
Volume			**Volume**		
teaspoons	5	milliliters	milliliters	0.033	fluid ounces
tablespoons	15	milliliters	liters	2.1	pints
fluid ounces	30	milliliters	liters	1.057	quarts
cups	0.24	liters	liters	0.264	gallons
pints	0.47	liters	cubic meters	35.315	cubic feet
quarts	0.95	liters	cubic meters	1.308	cubic yards
gallons	3.8	liters			
cubic feet	0.028	cubic meters			
cubic yards	0.765	cubic meters			
Temperature			**Temperature**		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius	Celsius	multiply by 9/5, then add 32	Fahrenheit
Radioactivity			**Radioactivity**		
picocuries	37	millibecquerel	millibecquerel	0.027	picocuries

1.0 INTRODUCTION

This operation and maintenance (O&M) plan describes the integrated monitoring program and administrative tasks that will be used to evaluate the implementation of the selected remedy for groundwater contamination in the 300-FF-5 Operable Unit (OU) (Figure 1-1). The selected remedy is an interim remedial action that involves restrictions on the use of the groundwater until such time as health-based criteria are met for the contaminants of concern (COCs) in the 300-FF-5 OU. An overview of the 300 Area OU boundaries is shown in Figure 1-1. The approach described in this plan is based on the Record of Decision (ROD) for the 300-FF-1 and 300-FF-5 OUs (EPA 1996) and the *Explanation of Significant Difference for the 300-FF-5 Record of Decision* (ESD) (EPA 2000). The interim remedial action for groundwater contamination is monitored natural attenuation (MNA) and institutional controls. This document describes the implementation plans for the MNA component of the interim remedial action. The Hanford Site-wide institutional control plan (currently being drafted by the U.S. Department of Energy [DOE]) will describe the institutional controls component of the interim remedial action.

The areal extent of the 300-FF-5 OU includes any groundwater affected by the 300-FF-1 and 300-FF-2 source sites and burial grounds. In addition to the above activities, this O&M plan will track groundwater contaminant plumes entering the 300 Area from offsite sources (i.e., 1100 and 200 Areas); however, the remedy selection decision does not apply to these contaminant plumes.

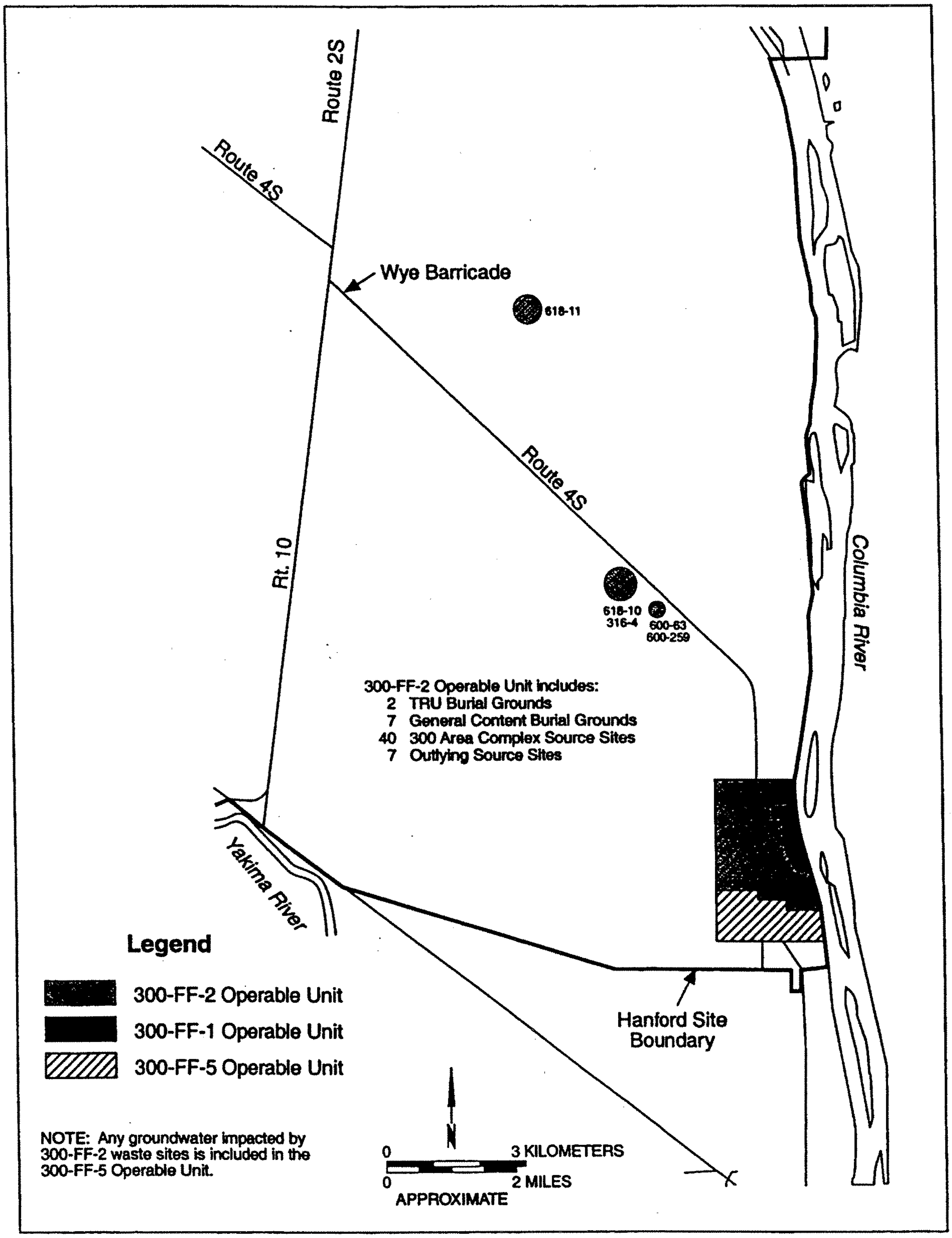
The interim remedial action for the 300-FF-5 OU is defined by the U.S. Environmental Protection Agency (EPA) as MNA. A key assumption of a remedy that relies on natural attenuation is that the contaminant plumes are, or will be, attenuating through either physical or biological processes to achieve drinking water standards throughout the entire groundwater plume within a reasonable time period. A "reasonable time period" is a site-specific determination and is dependent upon a comparison of the time that MNA would take to meet remedial action objectives (RAOs) relative to the time that active remedial technologies would take.

This O&M plan is designed to determine if the 300 Area groundwater plumes selected for the MNA remedy are attenuating in a reasonable time period. Groundwater plumes include uranium, tritium, strontium-90, dichloroethylene, trichloroethylene, and tetrachloroethylene (volatile organic analytes [VOAs]). Monitoring data will be routinely analyzed and presented to DOE and EPA to determine whether contaminant plumes are attenuating. If natural attenuation cannot be attained in a reasonable time period, an assessment of active remedial measures will be conducted. A determination of alternative concentration limits (ACLs) or technical impracticability would be considered if no active remedial measures are deemed available or practical. The goals of the 300-FF-5 O&M plan are to support the ROD and ESD by the following actions: (1) provide background information, (2) provide a detailed plan of action, (3) establish data analysis and reporting requirements, and (4) determine whether additional groundwater remedial actions are necessary to protect human health and the environment.

This O&M plan is organized as follows:

- Section 2.0 discusses the background of the Hanford Site and the 300-FF-1, 300-FF-2, and 300-FF-5 OUs.
- Section 3.0 discusses the conceptual models, geology, hydrogeology, hydrology, contaminant fate and transport, COCs, riverbank seeps, Columbia River water, and seep-associated biota.
- Section 4.0 discusses monitoring groundwater, groundwater seeps, the Columbia River, and seep-associated biota.
- Section 5.0 discusses the selected remedial action approach for groundwater.
- Section 6.0 discusses project management, including annual reporting requirements.
- Section 7.0 presents monitoring and deliverable activities, including a detailed project schedule through fiscal year 2006.
- The data quality objectives (DQO) summary report for the 300-FF-5 O&M plan, included in Appendix A, identifies monitoring and evaluation approaches for consideration.
- Maps of the 300 Area waste sites and contaminant plumes are included in Appendix B.
- Historical maps of the 300 Area uranium, tritium, strontium-90, dichloroethylene, trichloroethylene, and tetrachloroethylene plumes are included in Appendix C.
- The approval letters and selected sections of the 300 Area Process Trenches Groundwater Monitoring Plan are presented in Appendix D.

Figure 1-1. Overview of the 300 Area Operable Unit Boundaries.



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2.0 SITE BACKGROUND AND HISTORY

This section discusses general background and history of the Hanford Site; the 300 Area; and the 300-FF-1, 300-FF-2, and 300-FF-5 OUs. An overview map of the 300 Area is shown in Appendix B, Figure B-1.

2.1 HANFORD SITE AND 300 AREA

The Hanford Site is a 1,518-km^2 (586-mi^2) DOE facility located in southeastern Washington State. From 1943 to 1990, the primary mission of the Hanford Site was the production of nuclear materials for national defense. The Hanford Site's 300 Area industrial complex, which encompasses approximately 1.35 km^2 (0.52 mi^2), is located about 1.6 km (1 mi) north of the city of Richland, adjacent to the Columbia River. The 300 Area was developed as a nuclear fuels fabrication complex in 1943. In the early 1950s, construction began on research and development facilities, known as the Hanford Laboratories. Current activities in the 300 Area focus on peaceful uses of plutonium, reactor fuels development, liquid metal technology, life sciences research, and environmental restoration.

In July 1989, the Hanford Site was listed on the National Priorities List (NPL) pursuant to the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) as four NPL sites, the 100 Areas, 200 Areas, 300 Area, and the 1100 Area. Each of the NPL sites was divided into OUs, which are groupings of individual waste units based primarily on geographic area and common waste sources. The 300 Area consists of three OUs; 300-FF-1 and 300-FF-2 are source site OUs, and 300-FF-5 is a groundwater OU (in this context, "source" is used to distinguish soil waste sites from contaminated groundwater).

In anticipation of the NPL listing, the DOE, EPA, and Washington State Department of Ecology (Ecology) entered into the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1998) in May 1989. This agreement established a procedural framework and schedule for developing, implementing, and monitoring remedial response actions at the Hanford Site, as well as *Resource Conservation and Recovery Act of 1976* (RCRA) compliance and permitting. The Tri-Party Agreement provided the basis for initiating remediation activities at the Hanford Site, including the 300 Area OUs.

2.2 300-FF-1 SOURCE OPERABLE UNIT

The 300-FF-1 OU consists of solid waste and contaminated vadose zone soils for the major liquid/process waste disposal units in the 300 Area (e.g., north and south process ponds, process trenches and spoil areas, and the 618-4 Burial Ground). Detailed information about the 300-FF-1 OU can be found in the *Phase I and II Feasibility Study Report for the 300-FF-1 Operable Unit* (DOE-RL 1993b). A 300-FF-1 OU ROD was issued in 1996. The final selected remedy is remove, treat if necessary, and dispose of the contaminated soil at the Environmental Restoration

Disposal Facility (EPA 1996). The 300-FF-1 OU includes the process ponds and trenches, which are the contaminant sources for the groundwater plumes discussed below. The south process pond (316-1) was constructed in 1943. The north process pond (316-2) was constructed in 1948. The south and north process ponds operated simultaneously or alternately until both were retired and replaced by the process trench (316-5) in 1975. Liquid discharges to the ponds ranged from 1,500,000 to 11,400,000 L/day (400,000 to 3,000,000 gal/day). Discharges to the process trenches ranged from 4,400,000 to 6,500,000 L/day (1,152,000 to 1,728,000 gal/day), but decreased between 1985 and 1990 to less than 2,200,000 L/day (576,000 gal/day) due to a reduction in 300 Area operations (DOE-RL 2000b). Discharges to the process trenches ceased in 1995.

2.3 300-FF-2 SOURCE OPERABLE UNIT

The 300-FF-2 OU consists of 56 waste sites in the 300 Area and selected portions of the 600 Area. These waste sites can be categorized into four groups: waste sites in the 300 Area industrial complex (40 sites); waste sites north and west of the 300 Area industrial complex (outlying sites) (7 sites); general content burial grounds (7 sites); and transuranic-contaminated burial grounds (2 sites). A 300-FF-2 OU ROD was issued in April 2001 (EPA 2001b). The source sites within the 300 Area complex include trenches, storage areas, process plants, process sewers, french drains, and unplanned releases. Most 300 Area industrial complex sites lie beneath existing facilities and/or paved areas. Approximately 150 buildings and structures need to be removed to access 40 of the source sites requiring cleanup. More detailed 300-FF-2 information can be found in the *Limited Field Investigation Report for the 300-FF-2 Operable Unit* (DOE-RL 1997) and the *Focused Feasibility Study for the 300-FF-2 Operable Unit* (DOE-RL 2000b). An overview of the 300-FF-2 waste sites includes the following:

- Five sites in the 300 Area complex are underground sewer systems/piping. The 300 Area radioactive liquid waste sewer, the 300 Area retired radioactive liquid waste sewer, and the 309 holdup tank outfall pipeline (300-257) are abandoned systems. The 300 Area process sewer (300-15) and 300 Area retention process sewer (300-214) are active sewer systems. Many leaks and unplanned releases associated with the sewer systems have been documented. The volume of liquids that leaked from the systems and potential future impacts on groundwater and the Columbia River are unknown.

- The outlying source sites include trenches, cribs, dumping areas, storage areas, and unplanned releases. The 316-4 Crib is the only outlying 300-FF-2 source waste site that has been shown to impact groundwater. Groundwater monitoring results suggest that the uranium and tributyl phosphate contamination is localized.

- The general content burial grounds operated from the mid-1940s to the mid-1970s to support 300 Area fuel fabrication and laboratory activities. The burial grounds received a broad spectrum of chemical and radiological waste, as well as solid waste and debris.

- The transuranic-contaminated burial grounds are 618-10 and 618-11. These sites received wastes generated by fuel fabrication, fuel research, and testing during plutonium production. The 618-11 Burial Ground contains low-to-high activity waste and transuranic-contaminated waste buried in vertical pipe units, caissons, and trenches. The reported quantity of plutonium or other transuranic elements in the 618-11 Burial Ground is 5 to 10 kg (11 to 22 lb). The 618-10 Burial Ground contains transuranic-contaminated waste buried in vertical pipe units and trenches. The total quantity of plutonium or other transuranic elements within the 618-10 Burial Ground is estimated to be 1 to 2 kg (2 to 4 lb). In addition to a small amount of transuranic-contaminated waste, records indicate that the 618-10 Burial Ground trenches also contain high-activity waste and buried drums of oil. During stabilization activities at the 618-10 Burial Ground in 1983, a noticeable puddle of oil appeared after heavy equipment drove over a portion of the waste site, implying a loss of drum integrity.

2.4 300-FF-5 OPERABLE UNIT

Based on the ESD, the 300-FF-5 OU includes contaminated groundwater, soils contaminated by groundwater, saturated zone soils, and river water impacted by the waste sites in 300-FF-1 and 300-FF-2 OUs. The 300-FF-5 OU also includes groundwater impacted by waste sites 618-10, 316-4, and 618-11.

In January 1999, levels of tritium that greatly exceeded concentrations indicative of the sitewide plume were identified in well 699-13-3A, immediately downgradient of the 618-11 Burial Ground. Follow-up sampling in January 2000 at well 699-13-3A revealed a tritium concentration (8.1 million pCi/L) 400 times the drinking water standard. A multi-phase groundwater investigation was immediately launched. Phase 1 (February 2000) involved sampling 22 groundwater wells in a 5- to 8-km (3- to 5-mi) radius of the burial ground. Phase 2 (October 2000) involved resampling 10 wells, establishing 2 temporary groundwater sampling points, and installing a series of soil-gas sampling points to initially define the extent of the tritium plume by analyzing soil gas helium ratios. The results of this investigation were transmitted to the EPA in December 2001 and indicated that the 618-11 Burial Ground is the primary source of the groundwater tritium plume and the extent of the tritium plume is highly localized.

3.0 OPERABLE UNIT CONCEPTUAL MODEL

3.1 REGIONAL GEOLOGY (NORTH RICHLAND TO THE WYE BARRICADE)

This section discusses the regional structural geology and stratigraphy of the 300-FF-5 OU area. Information includes geology for the 300-FF-1 and 300-FF-2 OUs, which has been summarized from the *Limited Field Investigation Report for the 300-FF-2 Operable Unit* (DOE-RL 1997), *Focused Feasibility Study for the 300-FF-2 Operable Unit* (DOE-RL 2000b), and *Phase I Hydrogeologic Summary of the 300-FF-5 Operable Unit, 300 Area* (WHC 1992b), unless otherwise noted.

3.1.1 Geologic Structures

The major structural feature of the Hanford Site region is a series of subparallel, west-to-northwest-trending folds known as the Yakima Fold Belt (Figure 3-1). The Yakima Fold Belt consists of a series of segmented, narrow, asymmetric anticlines, whose ridges are separated by broad synclines or basins that, in many cases, contain thick accumulations of Neogene- to Quaternary-age sediments. The Pasco Basin is divided into the Wahluke and Cold Creek synclines, which are separated by the Gable Mountain anticline (Figure 3-1) (DOE-RL 1997). The 300-FF-5 OU lies above the axis of the northwest-southeast-trending Cold Creek syncline, near which it merges with the Pasco syncline. The syncline plunges gently northwestward at a gradient of approximately 5 m/km (25 ft/mi) (or about 0.25 degrees) toward the structural low of the Pasco Basin, approximately 16 km (10 mi) to the northwest of the 300 Area. The northwest corner of the 300-FF-5 OU extends to the vicinity of this structural low.

3.1.2 Stratigraphy

The 300-FF-5 OU is located along the southeastern margin of the Hanford Site. This area is similar to the rest of the Hanford Site in that a two-tiered stratigraphy is present, consisting of basalt/basalt-related volcanic and sedimentary rock and overlying sedimentary deposits. The principal units of the Hanford Site and 300-FF-5 OU area are, from oldest to youngest, as follows:

- Miocene-age Columbia River Basalt Group with interbedded Miocene Ellensburg Formation
- Miocene-Pliocene-age Ringold Formation
- Post-Ringold/Pre-Hanford deposits
- Pleistocene-age Hanford formation
- Holocene-age surficial deposits.

A general stratigraphic column is presented in Figure 3-2 (PNL 1998b). An east-west geologic cross section is presented in Figure 3-3 (DOE-RL 1997). A north-south geologic cross section is also presented in Figure 3-3 (DOE-RL 1997).

3.1.3 Columbia River Basalt Group

The Columbia River Basalt Group is the underlying bedrock for the 300-FF-5 OU. The 300-FF-2 limited field investigation report (DOE-RL 1997) states that the uppermost basalt units are the Ice Harbor Unit in the 300 Area and Elephant Mountain Member in the vicinity of the 400 Area. Depth to basalt varies from approximately 55 to 61 m (180 to 200 ft) below ground surface in the vicinity of the 300 Area to a depth of 90 to 123 m (295 to 400 ft) below ground surface in the vicinity of the 618-11 Burial Ground and is influenced by regional geologic structure (Figure 3-1).

3.1.4 Ringold Formation

The Ringold Formation unconformably overlies the Columbia River Basalt Group and is composed of fluvially derived sand and gravel. Thickness of the Ringold Formation ranges from approximately 29 to 44 m (95 to 144 ft) in the vicinity of the 300 Area (DOE-RL 1997) to approximately 85 m (275 ft) in the vicinity of the 618-10 Burial Ground.

The Ringold Formation in the 300-FF-5 OU can be divided into a lower mud-dominated sequence and an upper gravel-dominated sequence (DOE-RL 1997, WHC 1992b). The lower mud sequence is composed of crudely laminated clay and silt and appears to be continuous across the OU (DOE-RL 1997). The lower mud sequence is approximately 10 to 13 m thick (30 to 40 ft) in the 300 Area and thickens to the north and west (Figure 3-3). In the northern and northwestern area of the 300-FF-2 OU, Ringold Formation gravels (Unit A shown in Figures 3-2 and 3-3) underlie the lower mud unit. The Unit A gravels are not present in the 300 Area (WHC 1992b).

The upper gravel sequence (Units B, C, and E) consists primarily of mixed lithology gravel, with a quartz-feldspathic sand matrix. Gravel sequence thickness ranges from approximately 33 m (108 ft) in the vicinity of the 300 Area to approximately 66 m (217 ft) in the vicinity of the 618-10 Burial Ground. These units thicken to the north and west.

WHC (1992b) reported that two additional discontinuous mud/silt intervals within the Ringold Formation upper gravel sequence were present in the 300 Area. These units were not reported in the vicinity of the 618-10 and 618-11 Burial Grounds but were identified in wells drilled to the north. These mud units are significant because they may create semiconfined conditions in the 300 Area.

3.1.5 Post-Ringold/Pre-Hanford Deposits

Post-Ringold Formation gravels are not found in the vicinity of the 618-10 and 618-11 Burial Grounds or the 300 Area. They are found to the north and west of the 300-FF-5 OU.

3.1.6 Hanford Formation

The Hanford formation in the 300-FF-5 OU consists of unconsolidated glaciofluvial deposits emplaced by cataclysmic flooding in the Pleistocene age. The unit is divided into a gravel-dominated facies consisting of pebble-to-boulder clasts with a sand matrix (WHC 1992b), and a sand-dominated facies consisting of fine- to coarse-grained sand with interbedded gravel stringers. Lenticular sand and silt beds are found in gravel facies deposits.

The thickness of the Hanford formation ranges from 12 to 15 m (40 to 50 ft) in the 300-FF-5 OU. Little or no sand-dominated facies are present in the 300 Area. Well logs in the vicinity of the 618-11 Burial Ground show that approximately 6 m (20 ft) of sand-dominated facies is present. Both vertical and horizontal clastic dikes are known to be present in the Hanford formation in the 300-FF-5 OU (PNNL 2001c).

3.1.7 Holocene Surficial Deposits

Holocene surficial deposits consist of generally thin (<5-m [<16-ft]) layers of eolian-derived silt, sand, or reworked gravels deposited as a veneer across the Hanford formation. Thicker dune deposits are present in both the 300 Area and in the vicinity of the 618-10 and 618-11 Burial Grounds. Holocene or recent alluvial deposits of sand, silt, and gravel are found along the Columbia River.

3.1.8 300 Area (Near-River) Geology

300 Area geology consists of unconsolidated Ringold and Hanford formation sediments overlying basalt bedrock. Depth to basalt ranges from approximately 58 m (193 ft) at the western boundary of the 300 Area to approximately 53 m (175 ft) adjacent to the river. As discussed above, the basalt is structurally controlled and dips to the west and north. Immediately above the basalt, the fine-grained Ringold Lower Mud Unit is present across the 300 Area. This unit is up to 19 m (60 ft) thick in the southern 300 Area, decreasing in thickness to the north and west (WHC 1992b). The Ringold gravel sequences in the 300 Area are up to 21 m (70 ft) thick and are continuous across the 300 Area (WHC 1991). Two fine-grained units have been documented in the Ringold gravel sequence (WHC 1992b) and form sharply discontinuous lenses up to 10 m (30 ft) thick. Structure contour maps of the top of the Ringold Formation (WHC 1992b) show topographical features of up to 6 m (20 ft) in height. These features are consistent with scour effects from the glacial fluvial floods that deposited the overlying Hanford formation. The Hanford formation in the 300 Area is primarily coarse-grained, gravel-dominated facies, with discontinuous fine-grained lenses (WHC 1992b). Thickness of the Hanford formation in the 300 Area ranges from 9.1 to 21.3 m (30 to 70 ft), with the thickest units adjacent to the Columbia River.

3.1.9 618-10, 316-4, and 618-11 (Inland) Geology

Limited information is available for the 618-10 Burial Ground/316-4 Crib area. Seven wells are located in the immediate area, but these wells were drilled in the 1950s, and limited geologic information is available. Figure 3-3 depicts basalt bedrock at a depth of approximately 120 m (395 ft) below ground surface (DOE-RL 1997). Approximately 10 m (30 ft) of coarse-grained Ringold Unit A gravels are present. Overlying the Unit A gravels is approximately 10 m (30 ft) of finer grained Ringold Lower Mud Unit. The Ringold upper gravel sequence is approximately 70 m (230 ft) thick and has two thin fine-grained sequences. The Hanford formation is approximately 30 m (100 ft) thick. Based on the log of well 699-S6-E4A, the lower 15 m (50 ft) is probably gravel-dominated facies, and the upper 15 m (50 ft) is sand-dominated facies.

Basalt bedrock is located at a depth of approximately 92 m (300 ft) below the 618-11 Burial Ground. Based on a limited review of well driller's logs, Ringold Unit A gravels may be present at the 618-11 Burial Ground. A log of well 699-10-E12, west of the 618-11 Burial Ground (PNNL 2000b), suggests the Ringold Lower Mud Unit is approximately 13 m (45 ft) thick in that area. The Ringold upper gravel sequence is approximately 65 m (213 ft) thick at the 618-11 Burial Ground, and a discussion in the *Sampling and Analysis Plan for 618-11 Tritium Investigation Phase IIa Continuation: Plume Nature and Extent* (DOE-RL 2001) describes 1 to 3 m (3 to 10 ft) of surface topography on top of the Ringold Formation. This is consistent with erosional scour during emplacement of the Hanford formation.

The borehole geologic log of temporary well C3264 suggests that the Hanford formation at the 618-11 Burial Ground is approximately 14 to 15 m (45 to 50 ft) thick. There is a lower gravel-dominated sequence approximately 3 m (10 ft) thick, a middle sand-dominated interval approximately 6 m (20 ft) thick, and an upper gravel-dominated sequence approximately 6 m (20 ft) thick. The site is covered by a thin veneer of eolian sand deposits.

3.1.10 300-FF-5 Hydrology

The unconfined aquifer in the 300-FF-5 OU is within the Hanford and Ringold Formations. Hanford formation gravels have very high hydraulic conductivity, ranging from 3,600 to 10,000 m/day (12,000 to 32,800 ft/day) (DOE-RL 1995). Groundwater is present in the Hanford formation near the 300 Area Process Trenches (near the Columbia River) and west of the 618-11 Burial Ground. The Ringold Formation underlies the Hanford formation and consists primarily of a mixed lithology gravel in a silty sand matrix. The Ringold Formation is partially cemented and exhibits much lower hydraulic conductivities than the Hanford formation. Hydraulic conductivities range between 50 to 150 m/day (160 to 500 ft/day) in the Ringold Formation gravels (DOE-RL 1995).

Groundwater flow in the 300-FF-5 OU is generally to the east in the vicinity of the 618-10 and 618-11 Burial Grounds, and generally to the southeast to northeast in the vicinity of the 300 Area (PNNL 2001c). Figure 3-4 shows a regional water table map (PNL 1998b). Seasonal river stage variations affect the groundwater flow direction.

Based on shot hole, borehole, and well log data, it appears that the unconfined aquifer in the vicinity of the 618-11 Burial Ground is within the Ringold Formation. The Ringold Formation is partially indurated and exhibits much lower hydraulic conductivities than the Hanford formation. Although limited information is available, Ringold Unit A gravels may be present beneath the lower mud unit at the 618-11 Burial Ground, potentially creating a confined aquifer condition beneath the Ringold Lower Mud Unit.

3.2 CONTAMINANT FATE AND TRANSPORT

The conceptual model of the 300-FF-1 and 300-FF-2 near-river liquid waste sites is depicted in Figure 3-5, and the conceptual model of inland waste sites (e.g., 618-10 and 618-11) is depicted in Figure 3-6. Inland waste sites are generally located away from the river, on the west side of Stevens Drive (Route 4). Unlike the near-river conceptual model, river stage variations do not significantly influence groundwater levels under inland waste sites (618-10/316-4 and 618-11) because they are too far away from the Columbia River.

Table 3-1 identifies the expected predominant natural attenuation mechanisms for the 300-FF-5 OU contaminant plumes of concern. Dilution and dispersion are predominant mechanisms of attenuation for the majority of the areas of concern. However, other mechanisms including radioactive decay for tritium; adsorption for uranium and strontium-90; and degradation (hydrolysis and/or reductive dechlorination) for trichloroethylene, dichloroethylene, and tetrachloroethylene are also included. It is also plausible that uranium and strontium-90-bearing precipitates might be present that would impact contaminant transport.

The following sections describe the vadose zone transport characteristics, hydrogeology, and historic and current water table and hydraulic gradient features associated with the 300 Area near-river and inland sites.

3.2.1 Vadose Zone Transport

In the 300 Area near-river waste sites (Figure 3-5), liquids and suspended solids were discharged to the vadose zone, both directly (trenches and process ponds) and as a result of leaks in piping and process sewers. With the cessation of discharges to the process trench/process pond area in 1995, hydraulic head available to transport contaminants has been limited to natural recharge from rainwater. This has significantly reduced vadose zone contaminant migration and, consequently, reduced and potentially eliminated near-surface vadose zone source contributions to groundwater plumes. However, at high Columbia River stages, when river water is locally recharging the aquifer, the rise in the water table can remoblize residual uranium (and possibly other contaminants) located deep in the vadose zone, allowing contamination to enter the groundwater.

Figure 3-5 shows that the movement of water and contaminants from liquid waste disposal sites in the near-river vadose zone is expected to be primarily vertical. As discussed in BHI 1999b, the extent and rate of liquid movement are dependent on the degree of cementation, the amount of fines in the formation, initial saturation, and the characteristics of the solution pathway. Rainwater (or water from other sources that does not evaporate into the atmosphere) is expected to enter the strata at the surface and disperse in a relatively narrow, cone-like pattern through the gravel and/or sand facies of the Hanford formation. This distribution persists until lowpermeability silts or sandy silts are encountered, where vertical movement is restricted or slowed. The liquid then travels laterally to where the unit pinches out or intersects a clastic dike with a sand to granule infilling, where it can again migrate vertically. Alternately, sufficient hydraulic head can build up until breakthrough, and the liquid moves through and below the fine-grained unit. Figure 3-5 also shows how high Columbia River stages can influence the water table under near-river waste sites and remobilize residual contaminants, allowing them to enter the groundwater.

In the case of uranium (and for the primary purpose of assessing soil remedial actions), the migration potential of uranium remaining in vadose zone soil is currently being assessed with an ongoing uranium distribution coefficient (K_d)/leachability study (Section 5.6.3). Preliminary results indicate that up to 3% of the uranium soil mass is readily leachable, with the remaining 97% of the uranium soil mass more strongly bound to vadose zone soil. Figure 3-7 shows total uranium concentrations at two wells in the near-river 300 Area. Well 399-1-10A is adjacent to the Columbia River, and well 399-1-17A is adjacent to the 316-5 Process Trenches. Figure 3-7 shows a sharp upward trend in uranium concentrations after December 1994, when discharges to the process trenches ceased. It is inferred that the discharges of clean water to the trenches diluted the uranium in the groundwater, and when dilution stopped, concentrations rebounded. Figure 3-7 data suggest that uranium in the lower vadose zone is being remobilized by groundwater at high-river flow stages. This can be demonstrated by the correspondence between spikes in the uranium concentrations in well 399-1-17A and the recorded Columbia River high water. Peaks in total uranium are at, or slightly after, peak river stage. Data from well 399-1-10A adjacent to the river show the opposite effect. High-river stages correspond to low uranium concentrations, inferring that bank recharge/discharge is diluting groundwater concentrations. The dashed lines are 10-data-point moving average values. Both averages show uranium concentrations trending upward after December 1994 but decreasing after 1996.

Figure 3-6 shows the inland cross-sectional drawing for the 618-10/316-4 and 618-11 sites. In the inland vadose zone, movement of contaminants from liquid waste sites is also primarily vertical. However, there is no river influence at these inland sites and little chance for remobilization of sorbed vadose zone contamination without significant surface recharge, for example, the uranium and hydrocarbon compounds at well 699-S6-E4A (near the 316-4 Crib), coupled with the absence of contamination at downgradient wells, suggest that the contamination is localized and still bound within the soil under the crib (DOE-RL 2000a).

3.2.2 Historic and Current Water Table

Past groundwater investigations (PNL 1979, 1990b, 1991b, 1995b, 1998b) indicate that the 300 Area water table configuration is relatively consistent over time. The hydraulic gradient consistently reflects the regional flow toward the Columbia River, modified by river stage changes and the influence of the city of Richland sand filter located south of the 300 Area.

There does not appear to be evidence of a significant regional water table decline. Figure 3-4 shows the current water table for the Hanford Site, and water levels are shown on the maps included in Appendix B. Currently, the largest source of variation in the 300 Area water table is caused by river stage fluctuation.

The regional groundwater table near inland sites 618-10 and 316-4 has an easterly gradient toward the Columbia River. A comparison of 1994 and 2000 water table maps (PNL 1995b, PNNL 2001c) shows water table elevations to be relatively constant, with no significant decline. In January and February 2000, water levels were measured in wells and shot holes within the 600 Area, including locations near the 618-11 Burial Ground, in support of well decommissioning projects and the 618-11 tritium investigation. Figure 3-8 shows the water table map that was constructed using these data. Groundwater flow is generally from the west to the east across the 618-11 Burial Ground, although there appears to be a slight southeasterly component to the flow. River-stage fluctuation appears to have no effect at the 618-11 Burial Ground. Hydraulic head data in the vicinity of the 618-11 Burial Ground (Figures 3-9 and 3-10) show either a roughly constant water table or a slight rise in the water table over time.

3.2.3 Vertical Hydraulic Gradients

Previous research in the 300 Area (near-river) (WHC 1992b) shows a significant upward gradient. *Hanford Site Groundwater Monitoring for Fiscal Year 1997* (PNL 1998b) documents changes in head of up to 7.5 m (25 ft) in adjacent wells, with an upward gradient of 0.18 between the unconfined and semiconfined aquifers.

One piezometer cluster exists in the vicinity of the 618-10/316-4 (inland) area. This cluster, installed in 1996 in well 699-S6-E4C, has one set of paired water-level measurements taken in 1996 (Hanford Environmental Information System [HEIS]). The lower screen, set at 70.15 m (230.16 ft) below ground surface, had a hydraulic head of approximately 113.13 m (371.18 ft). The upper screen, set at approximately 44.8 m (146.99 ft) below ground surface, had a hydraulic head of approximately 112.93 m (370.52 ft). This gives an upward hydraulic gradient of 0.005. This estimate should be regarded with caution because it is based on limited information.

Supporting information exists regarding vertical hydraulic gradients in the vicinity of the 618-11 Burial Ground. Data from piezometer cluster 699-14-E6 (Figure 3-9), located approximately 1,600 m (1 mi) west of the burial ground, also show an upward hydraulic gradient of 0.003. However, data from the 699-E5-Q, 699-E5-R, 699-E5-S, and 699-E5-T piezometer cluster (Hanford Well Information System) (Figure 3-10), located approximately 2,800 m (1.7 mi) northwest of the burial ground, show a downward hydraulic gradient of 0.005.

3.3 300-FF-5 GROUNDWATER PLUME BACKGROUND AND HISTORY

Monitoring "areas of concern" in the 300-FF-5 OU includes specific locations (i.e., specific waste sites) and general areas (i.e., larger geographic areas influenced by several potential contaminant sources). The following subsections describe plumes that are currently being monitored.

3.3.1 Uranium Plume

The uranium plume is associated with the 300-FF-1 liquid disposal sites (e.g., process ponds). According to the 300-FF-1 feasibility study (DOE-RL 1993b), an estimated 18,141 kg (40,000 lb) of uranium was discharged to the south process pond (316-1); an estimated 15,873 kg (35,000 lb) of uranium was discharged to the north process pond (316-2); and discharges of uranium to the 316-5 Process Trenches between February 1985 and September 1986 were at a rate of 20 kg/month (44.1 lb/month). Discharges of uranium to the process trenches ceased after 1986.

Uranium concentrations increased in the groundwater immediately after discharges to the 316-5 Process Trenches ceased. The previously lower concentrations in the groundwater are inferred to be caused by dilution of groundwater, with large amounts of relatively clean cooling water discharged to the process trenches. These relatively clean cooling water discharges ceased in 1995. When discharge to the trenches stopped and the dilution no longer occurred, the concentrations rose to the high levels measured in 1995 through 1997. More recently, local groundwater uranium concentrations have declined (PNNL 2001c).

Uranium is widely distributed across the 300 Area groundwater. A yearly cycle of uranium concentration has been observed. Highest concentrations (see Section 3.2.1) generally occur in the spring when the Columbia River stage is high and the river water is recharging the aquifer. This rise in the water table mobilizes residual uranium from the lower vadose zone. The lowest uranium concentrations are generally in the fall or early winter when the Columbia River is at low stage. The highest uranium concentrations are in the northern part of the 300 Area, downgradient of the 316-5 Process Trenches and near the 316-1 South Process Pond. Because the 316-1 South Process Pond is downgradient of the process trenches, it is difficult to determine the relative contribution of each facility to the plume. The maximum concentration in fiscal year (FY) 1999 was 322 μg/L at well 399-2-2 during August 1999. The maximum concentration in FY 2000 was 234 μg/L at well 399-3-1 in September 2000. The 30-μg/L drinking water standard for uranium has been promulgated but does not take effect until December 8, 2003 (65 *Federal Register* 76708). The peak portion of the current uranium plume has moved downgradient toward the river, and the uranium concentration will likely decline near the process trenches unless high river stages mobilize residual uranium contamination in the lower vadose zone. Maps of the uranium plume are presented in Appendix B, Figures B-3 and B-4. Historical maps of the uranium plume are shown in Appendix C, Figures C-2 through C-9.

Precipitation, adsorption, dilution, and dispersion are the primary contributors to the natural attenuation of uranium. Uranium-238, the principle isotope of concern for 300-FF-5, has a half-life of 4.47 billion years. Therefore, radioactive decay is not a major contributor to uranium attenuation.

3.3.2 Volatile Organic Compound Plumes

According to the 300-FF-1 feasibility study (DOE-RL 1993b), 100,000 kg (220,500 lb) of trichloroethylene was discharged to the south process pond (316-1) and 100,000 kg (220,500 lb) of trichloroethylene was discharged to the north process pond (316-2) as part of the waste products associated with the fuels manufacturing process. Because of the volatility of the trichloroethylene, evaporation from the process ponds before percolation into the pond bottoms certainly occurred. No studies have been conducted to estimate these losses, but they were likely significant. Previous sampling conducted as part of the 300-FF-5 Phase I remedial investigation (RI) (DOE-RL 1994) included available wells that were screened over both the top and bottom of the unconfined aquifer. These data supported primarily using the wells screened at the top of the aquifer while still monitoring a limited number of wells screened at the bottom of the aquifer. Trichloroethylene was detected at 19 wells in the 300 Area in FY 2000. None of the results reported were at or above the maximum drinking water criteria of 5.0 μg/L. The highest concentration reported during FY 2000 (3.5 μg/L) was at well 399-1-16B (bottom of aquifer), near the 316-5 Process Trenches. There are two plumes of trichloroethylene in the 300 Area, the primary area of concern is confined to one well pair (399-1-16A [top of aquifer] and 399-1-16B [bottom of aquifer]) downgradient of the process trenches and is part of a large low-concentration (less than 1 μg/L) plume that covers a large portion of the 300 Area; and the second plume extends into the 300 Area from the southwest (PNNL 2001c). The trichloroethylene concentration in well 399-1-16B (downgradient of the process trenches) was 2.2 to 3.5 μg/L during FY 2000. Concentrations of trichloroethylene have decreased steadily in this well since 1997. Trichloroethylene was also detected in well 399-1-16A (screened at the water table), but concentrations were much lower during FY 2000 (in the range of 0.37 μg/L to 0.65 μg/L). The plume from the southwest emanates from the vicinity of the Horn Rapids landfill (PNNL 2001c). As indicated in Figure B-5 in Appendix B, concentrations from these two sources appear to have merged and are represented by one larger plume.

A plume of 1,2-dichloroethylene was detected in five wells in the 300 Area, but the 70-μg/L maximum drinking water criteria was exceeded only at two wells. Concentrations of dichloroethylene remained high in well 399-1-16B that monitors the bottom of the unconfined aquifer near the 316-5 Process Trenches. The dichloroethylene concentration was at a maximum in FY 1997 and FY 1998 and decreased slightly during FY 2000. The maximum dichloroethylene concentration in well 399-1-16B in FY 2000 was 170 μg/L, and the minimum concentration was 110 μg/L. The source of this constituent is presumed to be the 316-5 Process Trenches. Based on studies in the published literature, it is assumed that the observed 1,2-dichloroethylene was an anaerobic biodegradation product of trichloroethylene.

A plume of tetrachloroethylene (maximum drinking water standard of 0.8 μg/L) was detected in the 300 Area during FY 1998, but it is no longer observed and was virtually undetected in FY 2000. The tetrachloroethylene source was in the vicinity of the 316-5 Process Trenches and extended southeast toward the Columbia River. The plume continued during FY 1999, but the concentration within the plume decreased dramatically. The maximum reported value at well 399-1-17A, immediately downgradient of the process trenches, was 38 μg/L in FY 1998. The maximum in this well in FY 1999 was 4.0 μg/L and the maximum in FY 2000 was 0.65 μg/L. The plume maximum during FY 1999 was 7.0 μg/L at well 399-1-16A, but the yearly average was only 1.8 μg/L. During FY 2000, tetrachloroethylene was detected at only one well (399-1-17A), with a reported value of 0.65 μg/L (PNNL 2001c).

Maps of the trichloroethylene and tetrachloroethylene plumes are presented in Appendix B, Figures B-5 and B-6, respectively. Historical maps of the dichloroethylene, trichloroethylene, and tetrachloroethylene plumes are presented in Figures C-10 through C-12.

Dilution/dispersion and degradation are thought to be the major mechanisms of attenuation for the volatile organic compound plumes. The specific degradation process for the volatile organic compounds of concern is not currently known because multiple degradation processes are possible depending on the exact conditions present in the underlying soils. Chlorinated organic degradation typically follows one of two paths, hydrolysis and/or reductive dechlorination. Hydrolysis primarily yields alcohols (e.g., ethanol) or acids (e.g., acetic acid). These primary degradation products are readily biodegradable and have minimal toxicity and minimal effects on the potential solubility of other COCs.

Reductive dechlorination generally proceeds step-wise, with sequential loss of chlorine from the compound. For example, tetrachloroethylene dechlorinates to trichloroethylene, which dechlorinates to dichloroethylene (primarily to the cis isomer), ultimately dechlorinating to vinyl chloride and ethylene. Degradation of tetrachloroethylene/trichloroethylene may be the source of the dichloroethylene found in monitoring samples. Because of potential toxicity/carcinogen issues associated with the potential reductive dechlorination products of tetrachloroethylene/ trichloroethylene, monitoring efforts must include evaluation of dichloroethylene and vinyl chloride levels in the groundwater associated with this plume. Therefore, total 1,2-dichloroethylene, 1,1-dichloroethylene, and vinyl chloride are COCs. Cis-1,2-dichloroethylene and trans-1,2-dichloroethylene will only be requested to be analyzed if the levels of total 1,2-dichloroethylene warrant the special laboratory analysis.

3.3.3 Strontium-90 Plume

Solid and dissolved phases of strontium-90 may be found in the subsurface similar to the 100-N Area. Strontium-90 may be found in (1) the vadose zone soil and the residual soil moisture near, and immediately beneath, liquid waste disposal sites; (2) the contaminated vadose zone soil and soil moisture, which resulted from groundwater mounding away from the liquid waste disposal sites during their operation; and (3) the present-day unconfined aquifer and the groundwater contained therein (DOE-RL 1996).

A small portion of strontium-90 in groundwater may be in a dissolved phase and the rest present as a solid phase adsorbed to the aquifer matrix. Seasonal fluctuations in water levels cause temporary increases in strontium-90 concentrations in groundwater. Adsorption/desorption is considered a dynamic process because the strontium-90 is continually being adsorbed and desorbed, which maintains an equilibrium concentration of the contaminant in the solid and dissolved phases. The strontium-90 dissolved phase will be continually replenished by the solid-phase strontium-90 to maintain the chemical equilibrium.

Strontium-90 (8 pCi/L drinking water standard) continues to be detected at well 399-3-11, near the 324 Building. However, the more recently measured concentrations are not as high as those recorded in December 1995 (8.7 pCi/L). Since December 1995, the strontium-90 concentration has varied between 3 and 8 pCi/L. During FY 1999 and FY 2000, the recorded values were 4.0 pCi/L and 4.1 pCi/L. The reported concentration of 8.7 pCi/L in December 1995 was the only result greater than the drinking water standard since 1986. The source of the strontium-90 is unknown (PNNL 2001c). A historical map of the strontium-90 concentrations is presented in Appendix C, Figure C-13.

It is assumed that the behavior of strontium-90 in the 300 Area is similar to the behavior of strontium-90 in the 100-N Area (DOE-RL 1996). Decay is expected to be the major contributor to attenuation of strontium-90 in this area of concern because of a high desorption K_d. The half-life of strontium-90 is 29.1 years. Adsorption, desorption, dilution, and dispersion may also contribute to the attenuation of strontium-90.

3.3.4 Uranium/Tributyl Phosphate Plume Associated with the 618-10 Burial Ground and 316-4 Crib

The uranium/tributyl phosphate plume is discussed collectively in this document because of potential interactive effects between these two contaminants. While uranium is a hazardous substance under CERCLA, tributyl phosphate is not. No action level has been established for tributyl phosphate. Data gathered for the limited field investigation (DOE-RL 1997) suggested that groundwater was affected by the 316-4 Crib. The results of ongoing groundwater monitoring near the 316-4 Crib have been published in annual letter reports (BHI 1997a, 1998a, 1999a, 2001a). Uranium contamination in groundwater downgradient from the crib at well 699-S6-E4A was first detected in 1951 and reached a peak of 5,900 pCi/L in 1952. Uranium concentrations decreased to 21 pCi/L by 1956 (DOE-RL 2000b). Well 699-S6-E4A was reconditioned in 1995 to bring the well closer to current monitoring well construction standards. After reconditioning, increased concentrations of uranium (up to 768 µg/L in 1995) were measured in groundwater samples. The increases are attributed to loosening of fixed uranium concentrations (bound to iron oxide on the well casing) during reconditioning (BHI 2001a). Subsequent sampling produced lower values (108 µg/L in April 1996). Further reconditioning activities took place in September 1996 to install a 10-cm (4-in.) stainless-steel casing and a sand filter pack. In addition, the well was perforated above the water table and pressure grouted to create a surface seal. Uranium concentrations of 35 µg/L and 27 µg/L were obtained from samples taken in September 1996. Samples taken since September 1996 have shown a fluctuation in uranium concentrations, from a low of 21.7 µg/L in February 2001 to a high of 225 µg/L in June 1997 (HEIS). A map of the uranium plume at the 618-10 Burial Ground and the 316-4 Crib is presented in Appendix B, Figure B-4.

Tributyl phosphate was also detected in well 699-S6-E4A and reached a maximum concentration of 1,500 µg/L in 1996. Concentrations of tributyl phosphate have ranged between 200 and 720 µg/L from 1997 to 2000 (BHI 2001a). Tributyl phosphate was not detected in well 699-S6-E4A in June 1999 but was reported at 200 µg/L in both January 2000 and August 2000 samples (BHI 2001a). Examination of the existing data shows no direct correlation between elevated tributyl phosphate levels and elevated uranium levels.

From 1990 to 1998, concentrations of uranium were less than 5 µg/L, and tributyl phosphate was less than detection limits at wells downgradient from well 699-S6-E4A (DOE-RL 2000b). Based on this information and estimates of hydraulic properties/contaminant transport, the following conclusions were drawn:

- The travel time from well 699-S6-E4A to the Columbia River is estimated to be 7.3 years. If groundwater contaminants from effluents discharged to the 316-4 Crib during the 1950s and 1960s migrated at the same velocity as groundwater, the contaminants entered the Columbia River many years ago (DOE-RL 2000b).

- Even though groundwater travel time from well 699-S6-E4A to downgradient wells is approximately 43 days, uranium from sediments and well remediation at well 699-S6-E4A had not reached downgradient wells within 2 years of completion of remediation activities. This indicates that uranium migration is retarded with respect to groundwater movement (DOE-RL 2000b).

- Reported concentrations of uranium and hydrocarbon compounds at well 699-S6-E4A, coupled with the absence of contamination at downgradient wells, suggest that the contamination is localized and still bound within the soil underlying the crib (DOE-RL 2000a).

Uranium attenuation processes were addressed in Section 3.3.1. Dilution/dispersion and degradation are thought to be the major mechanisms of attenuation for tributyl phosphate. Degradation of tributyl phosphate in soils occurs through sequential loss of butyl groups (yielding butyl alcohol as a byproduct). Tributyl phosphate becomes dibutyl phosphate, then monobutyl phosphate, and ultimately phosphate ion. Butyl alcohol should readily biodegrade, has minimal toxicity, and produces minimal effects on the potential solubility of other COCs.

3.3.5 618-11 Burial Ground Tritium Plume

The 618-11 Burial Ground contains transuranic-contaminated waste that is buried in trenches, caissons, and pipe units. In response to an expedited response action proposal (DOE-RL 1993a), a groundwater monitoring well (699-13-3A) was installed immediately east and downgradient of the burial ground in 1995. Monitoring of groundwater between 1995 and 2001 was conducted as part of 300-FF-2 OU RI activities. This well has now been added to the 300-FF-5 OU monitoring network. Concentrations of radionuclide and inorganic constituents in groundwater samples remained consistent from the initial sampling in 1995 until 1998, when a possible increase in gross beta and total uranium was noticed. During this time frame, uranium concentrations ranged between 8.5 and 12.2 µg/L. Gross alpha and gross beta results have ranged from 5 to 8 pCi/L and from 14 to nearly 30 pCi/L, respectively (DOE-RL 2000b). Well 699-10-E12, downgradient of the burial ground and within 2 km (1 mi) of the river, had reported tritium values of 26,000 pCi/L in 1996 and 22,000 pCi/L in 1997. These values are typical "background" concentrations observed in the sitewide tritium plume (DOE-RL 2000b).

In December 2001, DOE transmitted to EPA the results of an investigation of groundwater contamination emanating from the 618-11 Burial Ground. The investigation indicated that (1) no other COCs appeared to be emanating from the burial ground, and (2) the groundwater tritium plume is relatively shallow, narrow, and of limited areal extent (see Figure 3-11). The width of the plume is about 300 m (984 ft) (measured between 20,000 pCi/L contours) at the burial ground fence and about 50 m (164 ft) at the end of the 20,000 pCi/L contour, about 1 km (0.6 mi) east of the burial ground. The drinking water standard for tritium is 20,000 pCi/L. The highest concentration observed within the past year was 5,290,000 pCi/L at well 699-13-3A. The furthermost downgradient measured value was 25,400 pCi/L, observed in a grab sample at the new well 699-13-0A. This plume blends with the 200 East Area tritium plume, east of Energy Northwest's Columbia Generating Plant, about 2 km (1 mi) east of the burial ground. A report on this investigation was issued called *Tritium Groundwater Investigation at the 618-11 Burial Ground, September 2001* (BHI 2001b).

Tritium was first analyzed in a groundwater sample collected from well 699-13-3A in January 1999, which was reported to contain 1,860,000 pCi/L of tritium. This value is far higher than the results from the surrounding wells, where concentrations ranging from 230 pCi/L to approximately 100,000 pCi/L are indicative of the sitewide tritium plume. Results from the January 2000 sample indicated a tritium concentration of approximately 8,140,000 pCi/L. In February 2000, well 699-13-3A and 21 other wells in the area surrounding the 618-11 Burial Ground were sampled for tritium and other radionuclides (DOE-RL 2000b). During the February 2000 sampling of well 699-13-3A, a tritium concentration of 7,230,000 pCi/L was detected (BHI 2001a). In August 2000, a tritium level of 8,380,000 pCi/L was detected (PNNL 2001c). The results of this investigation confirm that the 618-11 Burial Ground is the source of the elevated tritium. Further information is presented in *Evaluation of Elevated Tritium Levels in Groundwater Downgradient from the 618-11 Burial Ground Phase I Investigations* (PNNL 2000a). Figure 3-11 shows a map of the 618-11 tritium plume.

The results of BHI 2001b were used as part of an evaluation performed by DOE in October 2001 on the impacts of tritium contamination in groundwater from the 618-11 Burial Ground. The evaluation estimated the nature and extent of the tritium plume over time by using natural attenuation of the tritium plume coupled with numerical modeling evaluations. According to the *Evaluation of the Impact of Tritium Contamination in Groundwater from the 618-11 Burial Ground at the Hanford Site* (PNNL 2002), the travel time for the 618-11 tritium plume to reach the Columbia River is estimated to be from 43 to 166 years. Modeling results that best fit the observed plume geometry indicate a realistic contaminant travel time of 70 to 80 years from the burial ground to the river, with a maximum concentration of 5,500 pCi/L at the river. The maximum concentrations at the river are estimated to be from 730,000 to 700 pCi/L. The shorter travel time leaves little time for radioactive decay, and therefore the shorter travel time is associated with the higher concentration at the river. The tritium flux to the river is estimated to be from 0.46 to 480 Ci/yr. The 480 Ci/yr value is very conservative, due to assumptions about dispersion and average concentrations, since there is only an estimated 285 Ci in the groundwater plume currently. For comparison, the tritium plume originating in the 200 Areas is discharging 260 Ci/yr to the river. No impact is expected at the water supply wells that are currently being used for WNP-1 and the Columbia Generating Station (formerly called WNP-2) at Energy Northwest.

Radioactive decay is expected to be the major attenuation mechanism for tritium. The half-life of tritium is 12.5 years. Dilution and dispersion are also expected to be important factors.

3.3.6 Plumes Migrating into the 300 Area

A trichloroethylene plume extends into the 300 Area from the southwest (PNNL 2001c). The plume is detected at wells screened at the water table. The highest concentration in this plume within the 300 Area during FY 2000 was at well 399-4-1, where the reported result was 2.3 µg/L (the drinking water maximum contaminant level [MCL] is 5.0 µg/L). The only identified source of trichloroethylene in this plume is offsite, southwest of the Horn Rapids landfill (1100 EM-1 sites). A map of the trichloroethylene plume is presented in Appendix B, Figure B-5. A technetium-99 plume is also reportedly entering the 300 Area from the southwest (EPA 2001a).

Nitrate concentrations above background levels are present in all wells sampled in the 300 Area. Only two of the wells, 399-5-1 (100.0 mg/L) and 699-S27-E14 (60.6 mg/L), in the southwestern and southern portions of the 300 Area, respectively, reported levels exceeding the drinking water MCL of 45 mg/L in 2000. The source of the nitrate is believed to be offsite industry and agriculture (PNNL 2001c). A map of the nitrate plume is presented in Appendix B, Figure B-7.

The southern portion of the site-wide tritium plume from the 200 Areas extends into the 300 Area with concentrations less than the maximum drinking water criteria of 20,000 pCi/L. Tritium concentrations decrease from greater than 10,000 pCi/L to less than 100 pCi/L in a southwesterly direction across the 300 Area. The 10,000-pCi/L isopleth extends through the 300 Area and exhibits little change since FY 1999 (PNNL 2001c). Maps of the tritium plume are presented in Appendix B, Figures B-8 through B-10.

3.4 RIVERBANK SEEPAGE, COLUMBIA RIVER WATER, AND RIPARIAN BIOTA

Columbia River water originates from surface runoff and groundwater. Many point and nonpoint sources contribute to the water quality of the Columbia River. Some of these sources include surface water runoff from agricultural areas, stormwater drainage systems, wastewater treatment plant outfalls, and groundwater from the Hanford Site. Groundwater from the Hanford Site enters the river via subsurface discharge through the riverbed and by seeps along the riverbank. During high-river stages, "bank recharge" occurs, and sediments several hundred feet from the river and normally above the water table can be saturated by river water. This temporary saturation of the normally unsaturated (vadose) zone can mobilize contaminants.

Several seeps are located along the riverbank in the vicinity of the 300 Area (see Figure 3-5). These seeps are best observed at low-river stages. Biota around the seeps may be directly exposed to, absorb, or drink seep and river water, and accumulate contaminants.

3.4.1 Riverbank Seep Background and History

Detailed information about the riverbank seeps can be found in the *1988 Hanford Riverbank Springs Characterization Report* (PNL 1990a) and *300-FF-5 Operable Unit Field Sampling Plan for Tasks 5B and 5C – Riverbank Springs and Near-Shore River Water and Sediment* (WHC 1992a). In addition, some of these seeps were sampled twice as part of 300-FF-5 remedial investigation/feasibility study (RI/FS) activities (DOE-RL 1994, 1995). The first event (September 1992) took place under extreme low-flow conditions, whereas the second event (June 1994) was intended to represent an average-flow condition. The results from the two seep sampling events can be found in *Sampling and Analysis of 300-FF-5 Operable Unit Springs and Near-Shore Sediments and River Water* (WHC 1993b) and the *Remedial Investigation/ Feasibility Study Report for the 300-FF-5 Operable Unit* (DOE-RL 1995).

According to the *Hanford Site Environmental Surveillance Master Sampling Schedule* (PNNL 2001b), grab sampling of Columbia River seep water is scheduled to be conducted annually along the shoreline near the 300 Area at seeps S1178 (seep #7) and S1180 (seep #9). The samples will be analyzed for alpha (gross alpha activity of sample), beta (gross beta activity of sample), tritium, strontium-90, isotopic uranium (uranium-234, uranium-235, and uranium-238), iodine-129, gamma scan (analysis of photon energy spectrum for individual photon-emitting radionuclides), ICP-3 (major metals by inductively coupled plasma [ICP] spectrometry; samples unfiltered unless otherwise noted), ICP-3 filtered, anions (major anions; generally chloride, fluoride, nitrate, nitrite, sulfate), and volatile organic analytes (VOAs). The results from these sampling efforts will be included in Pacific Northwest National Laboratory's (PNNL's) annual Hanford Site monitoring reports.

3.4.2 Columbia River Background and History

The Columbia River forms the eastern boundary of the 300-FF-5 OU. Water quality in the Columbia River near the 300-FF-5 OU is listed as Class A, excellent, according to the state of Washington. Class A waters are suitable for raw drinking water, recreation, and wildlife habitat. According to the *Hanford Site Environmental Surveillance Master Sampling Schedule* (PNNL 2001b), Columbia River water sampling is conducted annually on a transect at Hanford River Mile 43.1 (near the 300 Area) and also along the shoreline (near the 300 Area) at sites 8240, 8241, 8242, and 8243 (Hanford River Miles 41.5, 42.1, 42.5, and 42.9) (see maps in Appendix B). The samples are analyzed for "Lo tritium" (the analytical procedure includes electrolytic enrichment, which allows a lower detection limit), strontium-90, isotopic uranium (uranium-234, uranium-235, and uranium-238), ICP-3 (major metals by ICP spectrometry; samples unfiltered unless otherwise noted), ICP-3 filtered, and anions (chloride, fluoride, nitrate, nitrite, and sulfate).

In addition to Columbia River monitoring conducted by PNNL and previously by Westinghouse Hanford Company, nonradiological water quality monitoring has also been performed by the U.S. Geological Survey (USGS) in conjunction with the National Stream Quality Accounting Network program. The USGS samples are collected quarterly along Columbia River transects at the Vernita Bridge and city of Richland pumphouse. Sample analyses are performed at the USGS laboratory in Denver, Colorado, for numerous physical and chemical constituents (PNNL 2000b). Transect sampling was initiated as a result of a special study conducted during 1987 and 1988 (PNL 1993a). That study concluded that, under certain flow conditions, contaminants entering the river from the Hanford Site are not completely mixed when sampled at routine monitoring stations located down river. The incomplete mixing of contaminants with the river water is most pronounced during periods of extended low river flow. Incomplete mixing results in a slightly conservative (high) bias in the data generated using the routine, single-point sampling system at the city of Richland pumphouse (i.e., contaminants hug the western edge of the river) (PNNL 2000b).

The 1999 USGS nonradiological results were comparable to those reported during the previous 5 years. Applicable standards for a Class A-designated surface water body were met. During 1999, there was no indication of any deterioration of water quality resulting from site operations along the Hanford Reach of the Columbia River (PNNL 2000b). A summary of the results includes the following:

- Nitrate concentrations were slightly elevated, compared to mid-river samples, for the Benton County shoreline near the city of Richland pumphouse. Nitrate, sulfate, and chloride concentrations were slightly elevated, compared to mid-river samples along the Franklin County shoreline at the city of Richland pumphouse transects. These elevated results are likely from groundwater seepage and the irrigation return canal associated with extensive irrigation north and east of the Columbia River (PNNL 2000b).

- The mean tritium concentration along the city of Richland pumphouse transect in 1999 was lower than monthly composite samples from the pumphouse (this illustrates the conservative bias of the fixed-location monitoring station). Nitrate contamination of some Franklin County groundwater has been documented by the USGS and is associated with high fertilizer and irrigation water use. Nitrate, chloride, and sulfate concentrations were slightly elevated, compared to mid-river samples for both shorelines at the 300 Area (PNNL 2000b).

- The 1999 mean concentrations for strontium-90 and total uranium from transect samples at the city of Richland pumphouse were similar to monthly composite samples from the pumphouse, indicating that strontium-90 and total uranium levels in water collected from the fixed-location monitoring station are representative of the average concentrations in the river at that location (PNNL 2000b).

- The highest total uranium concentration in 1999 was measured near the Franklin County shoreline of the 300 Area transect. This concentration likely resulted from groundwater seepage and irrigation water return canals on the east side of the river that contained naturally occurring uranium (PNNL 2000a).

Two Columbia River "mini" river transect studies were conducted to support 300-FF-5 RI/FS activities (DOE-RL 1994, 1995). The first event took place under extreme low-flow conditions (September 1992), whereas the second event (June 1994) represented a more average-flow condition. Sample points were immediately upstream of seep #6 (S1176) and immediately downstream of seeps #9 (S1180) and #11 (S1182). Samples were collected at 1, 3, and 6 m (3, 10, and 20 ft) from the shoreline at two depths, along the river bottom and at mid-water depth. The results from the September 1992 sampling event generally indicated that contaminant concentrations were highest close to the riverbank and lowest away from the riverbank. Concentrations were also generally found to be higher at the downstream end of the 300 Area when compared to upstream or mid-portion locations. The maximum values for uranium isotopes, tritium, trichloroethylene, and technetium-99 all occurred at the furthermost downstream location sampled (seep #11, S1182), and were thought to be associated with an accumulation of upstream groundwater discharges. During the June 1994 sampling, none of the COCs exceeded primary or secondary drinking water standards (MCLs).

3.4.3 Potentially Affected Biota Background and History

Biota around the seeps may be directly exposed to, absorb, or ingest contaminated seep and river water. This section summarizes radionuclide concentrations measured in biota from the 300 Area shoreline collected over the last 10 years. Error terms (when provided) are the 2 sigma (95% certainty) total analytical propagated error. The analytical error values represent a +/- "variance" around the reported analytical results. Biota sampling data are reported in the annual Hanford Site environmental monitoring reports (PNL 1990b, 1991a, 1992, 1993b, 1994, 1995a, 1996, 1997, 1998a; PNNL 1999, 2000b).

- A cottontail rabbit was collected and analyzed in 1994. Cobalt-60 and cesium-137 were below detection in the muscle. The concentration of strontium-90 in the bone was 0.12 ± 0.05 pCi/g wet wt. Rabbit samples were not analyzed for uranium.

- Table 3-2 summarizes radionuclide data for freshwater (Asian) clam (*Corbicula* sp.) muscle and shell collected from 1990 through 1994. All radionuclide concentrations in clam muscle from along the river in the 300 Area were below the detection limit; however, uranium was not analyzed in these samples.

- Table 3-3 summarizes radionuclide data for fish fillet (muscle) and offal (formally identified as "carcass"; consists of remains after fillets and viscera have been removed [i.e., skin, head, and skeleton, with fragments of muscle]). Samples were collected from 1990 through 1996. All radionuclide concentrations in fish muscle and offal from along the river in the 300 Area were at or below the detection limit; however, uranium was not analyzed in these samples. According to the *Hanford Site Environmental Surveillance Master Sampling Schedule* (PNNL 2001b), PNNL sampling of carp near the 300 Area is scheduled to occur every 2 years, with the next sampling event in June 2002. The fillet samples will be analyzed for gamma scan (analysis of photon energy spectrum for individual photon-emitting radionuclides). The offal samples will be analyzed for strontium-90.

- From 1990 through 1992, extensive riparian vegetation sampling was conducted along the Benton County shoreline of the Hanford Reach, including the 300 Area (PNL 1993c). As part of this effort, milfoil (an aquatic vascular plant) was collected at Vernita and the

300 Area and analyzed for uranium. The following points summarize this study by PNL (1993c):

- Tritium concentrations in water distilled from riparian vegetation were elevated when compared to water distilled from the reference location above the Vernita Bridge. Concentrations ranged from below detection (<300 pCi/L distillate) to a maximum value of 2,700 pCi/L in riparian vegetation at the 300 Area. Concentrations of tritium at the reference location were all below the detection limit (approximately 300 pCi/L distillate).

- Cobalt-60, cesium-137, and strontium-90 concentrations in 300 Area riparian vegetation were comparable to the reference location above the Vernita Bridge.

- Technetium-99 was not detected in samples collected from the 300 Area but was detected in two samples from the old Hanford townsite.

- Plutonium-238 and plutonium-239/240 concentrations were at or below the detection limit throughout the Hanford Reach (including the 300 Area).

- The highest uranium concentrations were in wild onions growing in exposed cobble along the river in the 300 Area (0.34 pCi/g dry wt). Plants collected from the 300 Area had higher uranium concentrations than those from Vernita and throughout the site, but statistical analyses of these data did not produce a distinct trend for elevated uranium at any single location.

- Uranium concentrations were statistically higher in milfoil collected in 1994 from the 300 Area than in milfoil collected from the Vernita area. The molar ratio of milfoil uranium-235 to uranium-238 was higher in the 300 Area than in the Vernita area.

Samples of shoreline vegetation collected in 1994 and 1998 along the 300 Area did not contain measurable concentrations of uranium-238. These shoreline samples were collected upstream of seep #7 (S1177). In 1999, samples of mulberry tree leaves and reed canary grass collected at seep #7 (S1177) were analyzed for uranium (Table 3-4). Concentrations of cobalt-60, cesium-137, plutonium-238, and plutonium-239/240 were below detection levels in the mulberry tree leaves and reed canary grass collected in 1999. Strontium-90 and technetium-99 (mulberry only) were also analyzed in the 1999 samples. All radionuclide concentrations from the 1994 to 1999 vegetation sampling are summarized in Table 3-5.

Another biota study conducted in the 300 Area included reed canary grass, mulberry, Great Basin pocket mice, periphyton, and macrophyte colonies (WHC 1993a). Findings of this study are as follows:

- Uranium was statistically higher in reed canary grass samples from the 300 Area than in upriver samples.

- Uranium was higher in 300 Area mulberry samples than upriver samples.

- Carcass tissues of Great Basin pocket mice showed significant differences in uranium concentrations among sampling stations, with the highest concentrations near the 300 Area process ponds.

- The periphyton results showed that although the highest concentrations for most contaminants were found at the furthermost downstream 300 Area station, there was little evidence of a downstream trend in contaminant levels, and there was no evidence of stress in these organisms.

- Macrophyte samples showed higher concentrations of uranium in the 300 Area when compared to upriver.

The ROD for the 300-FF-1 and 300-FF-5 OUs (EPA 1996) reported that the ecological risk assessment showed that impacts were insignificant. For 300-FF-1, the evaluation showed that the Great Basin pocket mouse may potentially be affected from exposure to onsite contamination. The increased risk would not have a significant impact on the mouse population and is not transferred to any predator. Remedial actions for the protection of human health will also provide protection for the Great Basin pocket mouse. For the 300-FF-5 OU, individual organisms might receive small doses of contaminants, but there would not be a significant dose to any population, and contaminants are not carried up the food chain. Therefore, no ecological risks to major species were identified.

Figure 3-1. Geologic Structures of the Pasco Basin.

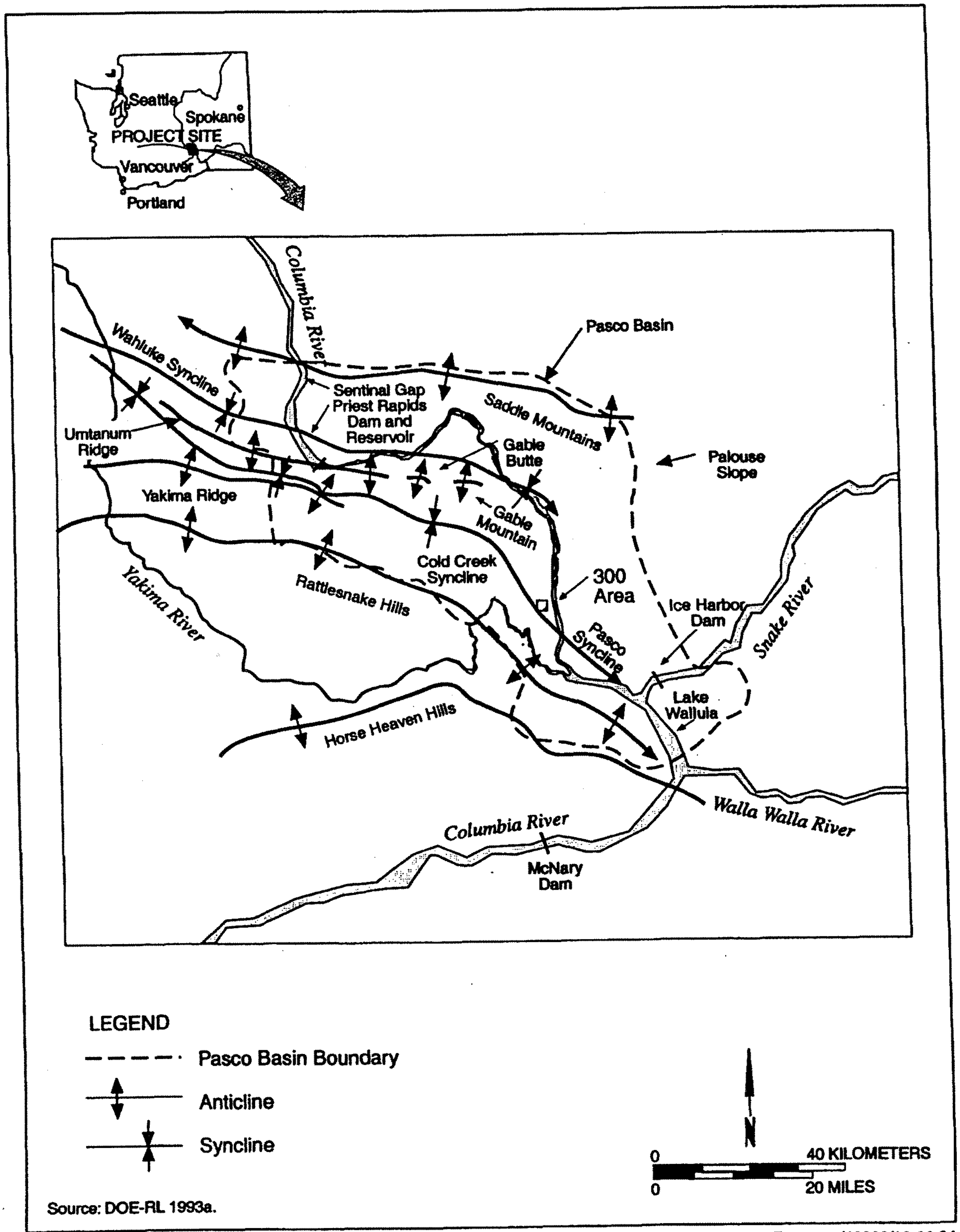

Figure 3-2. Generalized Geologic Stratigraphy.

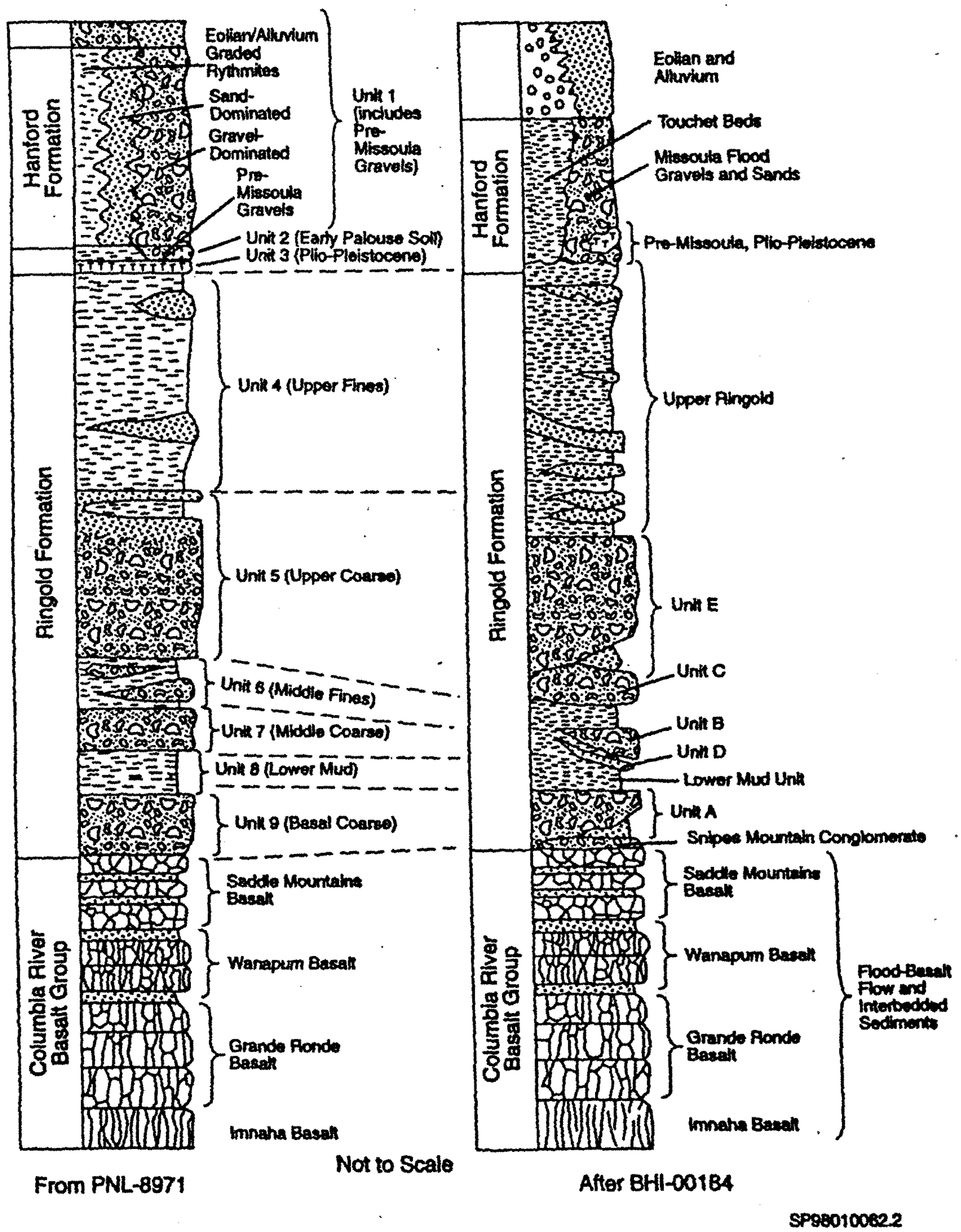

Figure 3-3. Geological Cross Sections. (1 of 3 Pages)

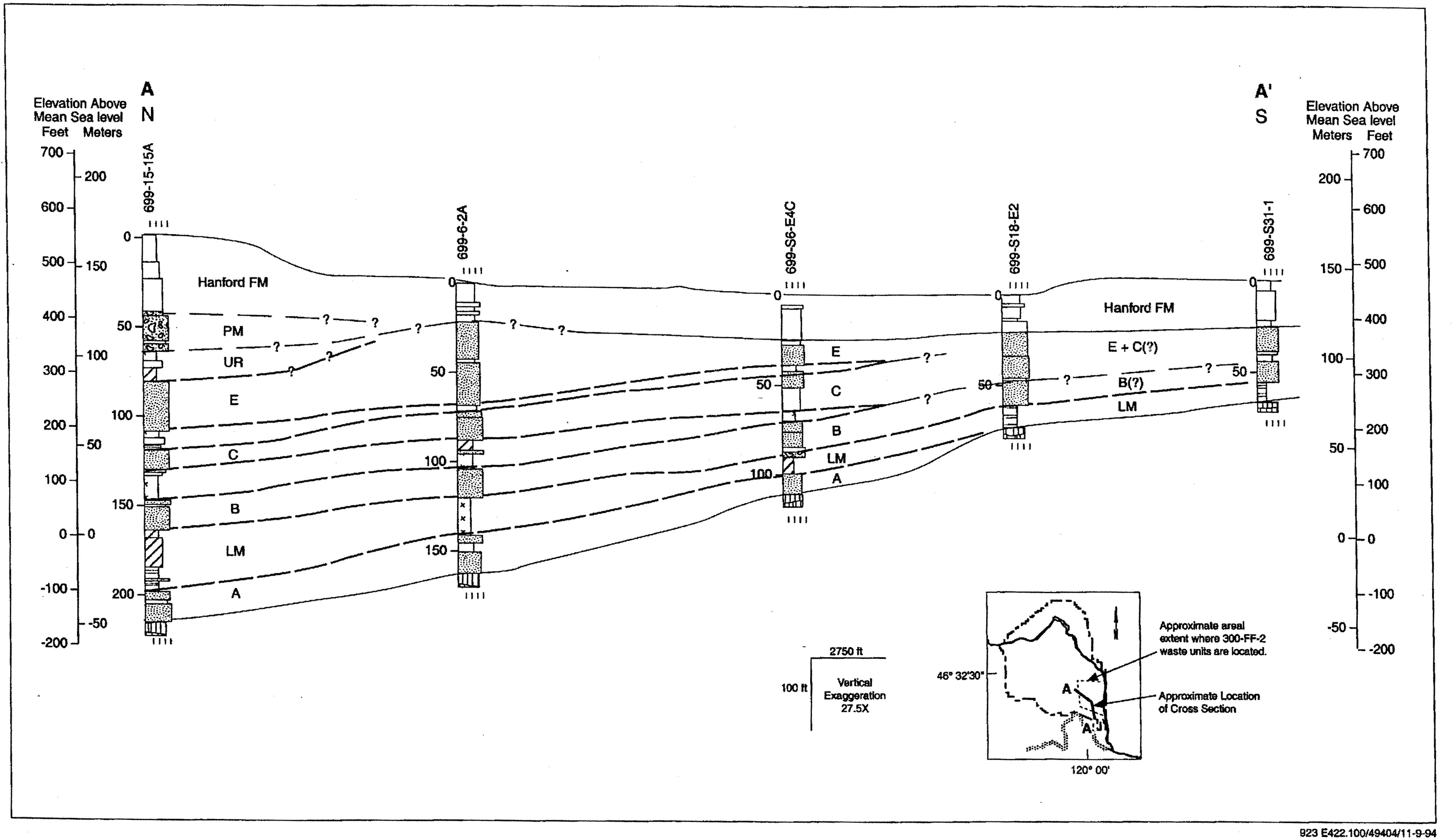

Figure 3-3. Geological Cross Sections. (2 of 3 Pages)

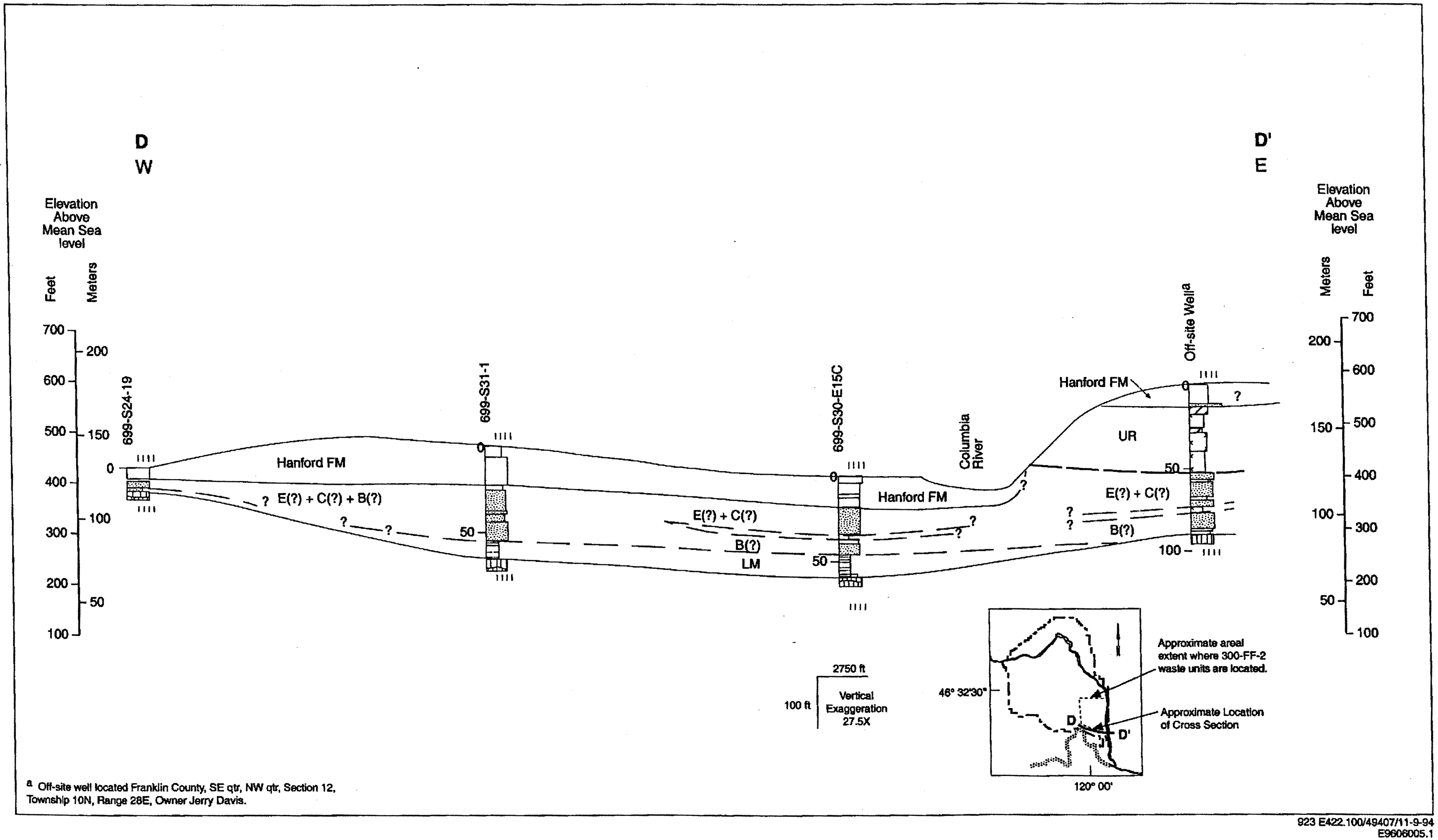

Figure 3-3. Geological Cross Sections. (Page 3 of 3)

Explanation

Additional Lithologic Symbols, Includes Subordinate Lithologies

- Clay-rich
- Silt-rich
- Sandy
- Pebbly
- Bouldery
- Pedogenic.Calcium Carbonate
- Paleosol
- Basalt
- Cemented
- Tuffs

Grain Size Scale, Indicates Dominant Lithology in Interval

- Boulder Gravel
- Pebble/Cobble Gravel
- Sand
- Clay and Silt

Other Symbols

——?——?—— Formation Contact, ? where inferred

Unit Contact, ? where inferred

Abbreviations

PM – Pre-Missoula gravels
PP – Plio-Pleistocene/early Palouse interval
UR – Upper unit, Ringold Formation
E – Unit E, Ringold Formation
C – Unit C, Ringold Formation
D – Unit D, Ringold Formation
B – Unit B, Ringold Formation
LM – Lower Mud unit, Ringold Formation
A – Unit A, Ringold Formation

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Figure 3-4. Hanford Site Regional Water Table Map, March 2000.

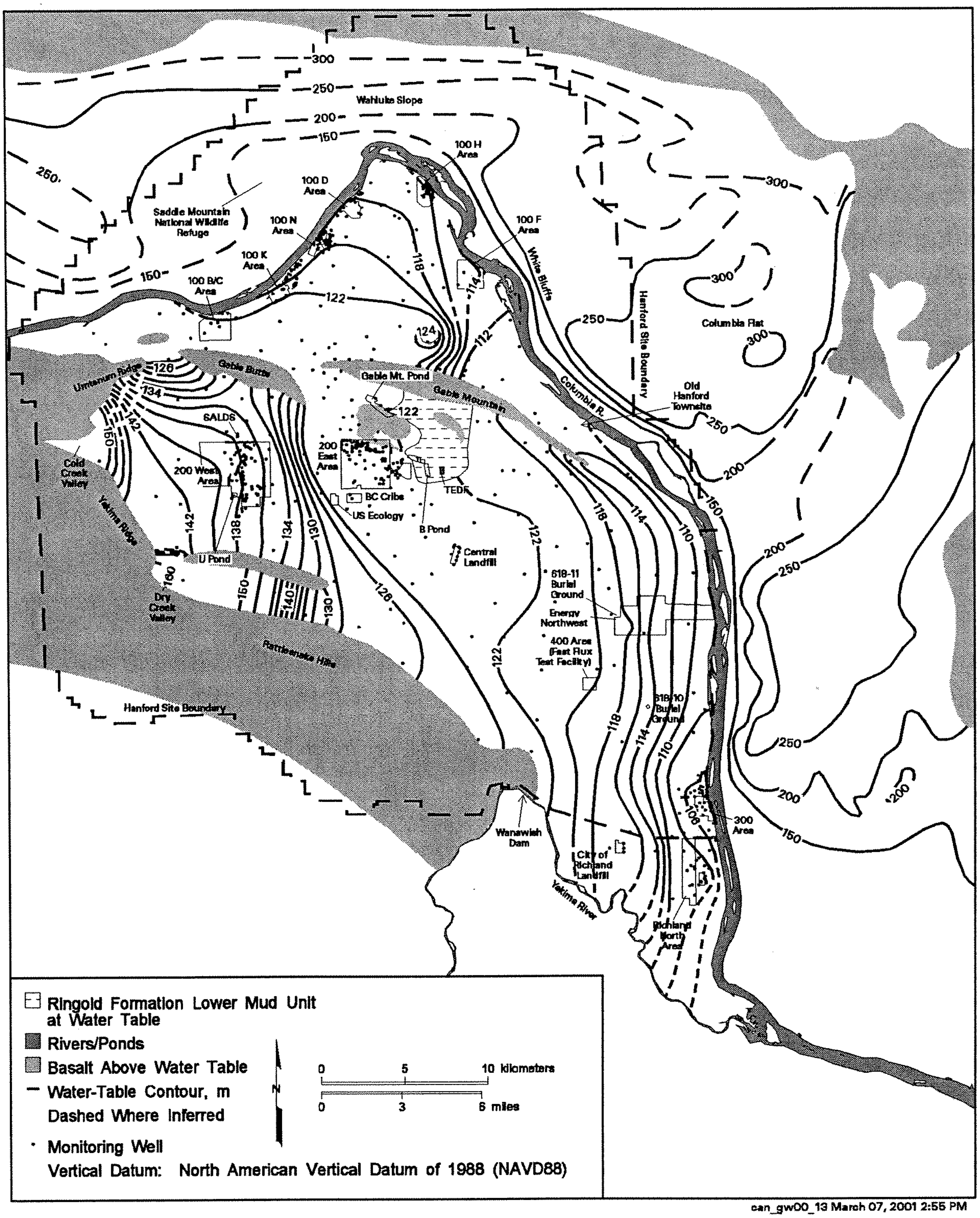
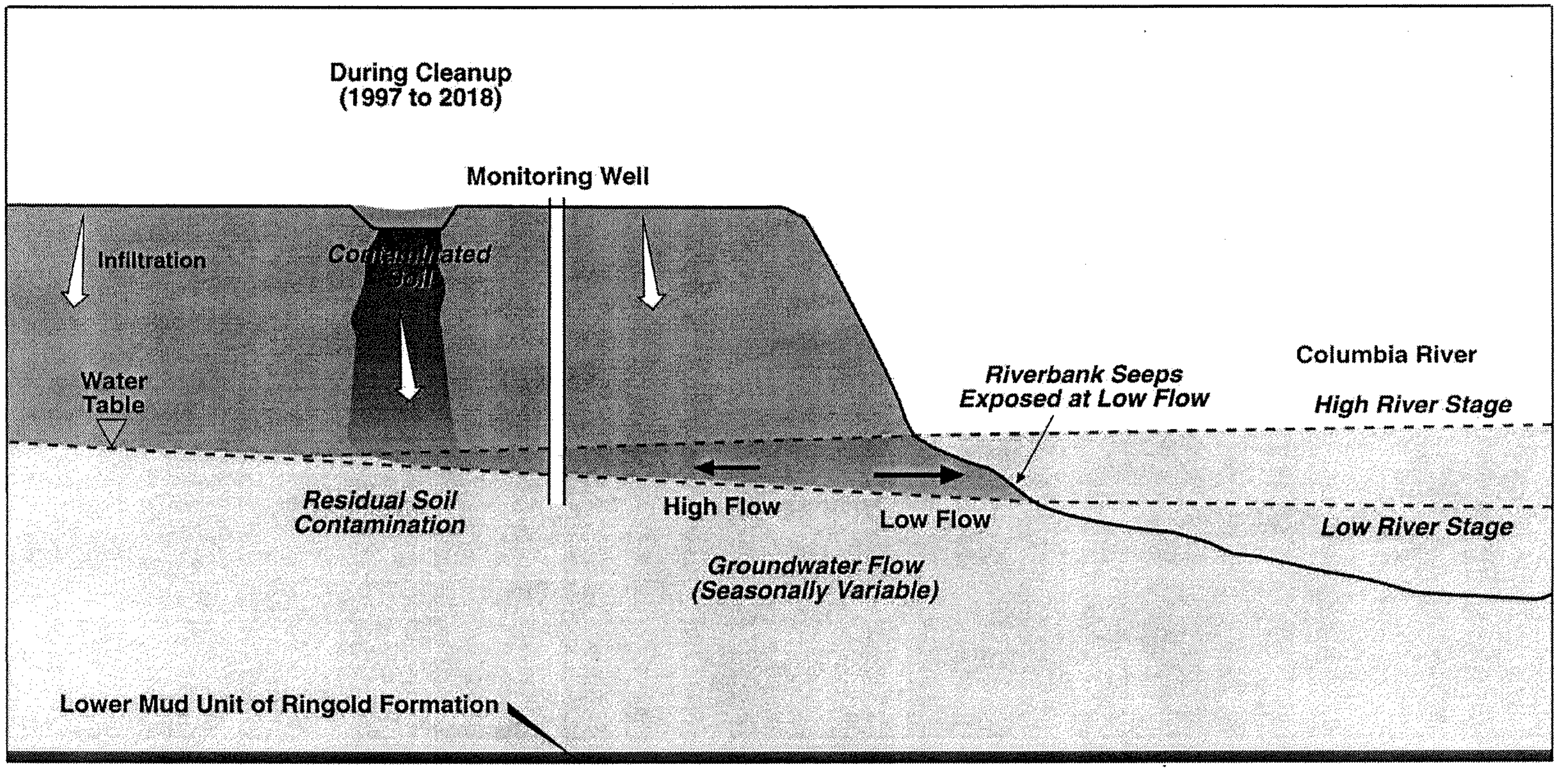


Figure 3-5. Near-River Schematic Diagram of Contaminant Movement.[a]



[a] Sites generally east of Stevens Drive, that are influenced by Columbia River stage (e.g., 316-5 [process trenches]. Current contaminant distribution in the vadose zone is an artifact of historical liquid waste disposal during 300 Area operations.

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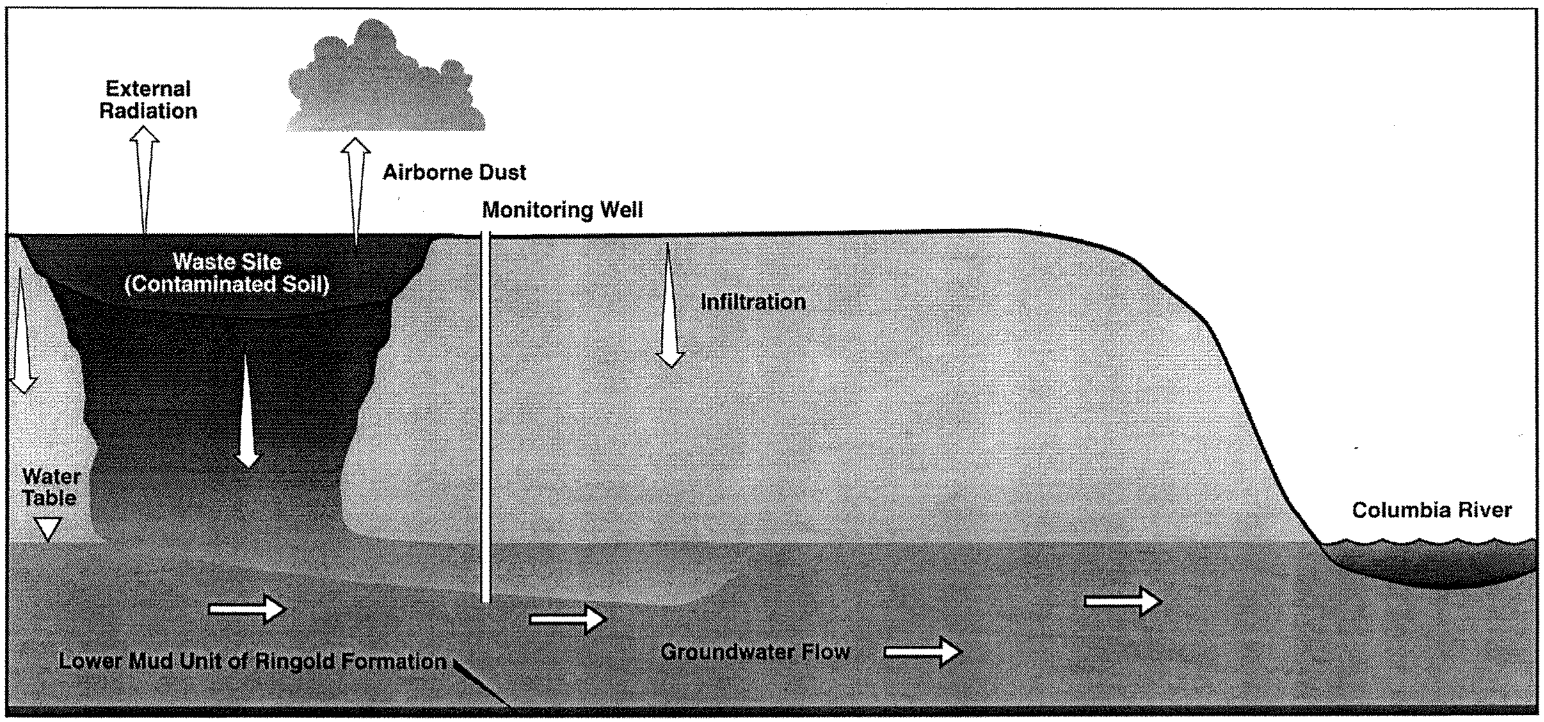
Figure 3-6. Inland Schematic Diagram of Contaminant Movement.[a]



[a]Sites generally west of Stevens Drive, that are not influenced by Columbia River stage (e.g., 618-10, 316-4, 618-11).

Figure 3-7. Select 300 Area Groundwater Well Uranium Concentrations.

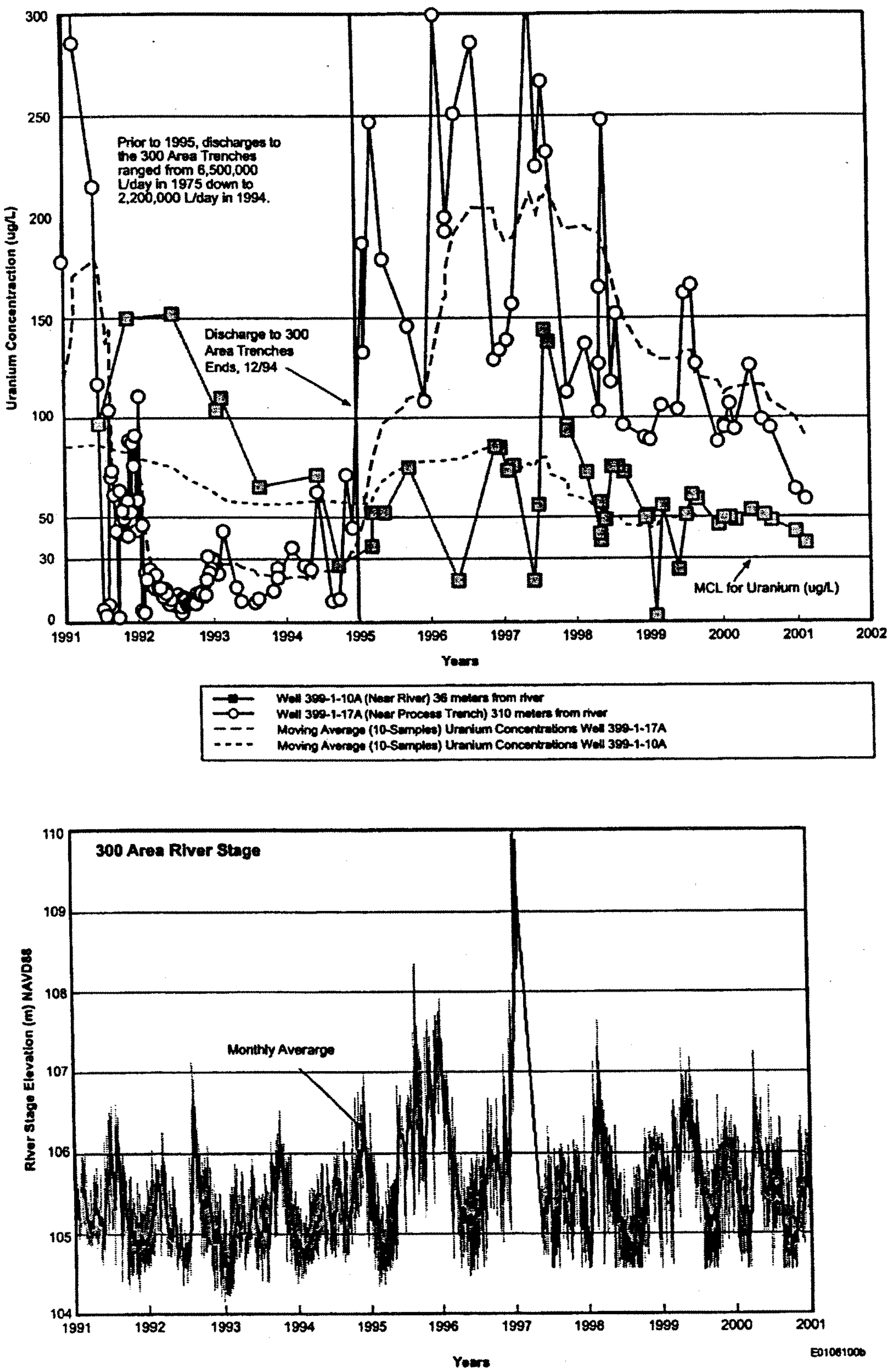


Figure 3-8. 618-11 Water Table Map (January/February 2000).

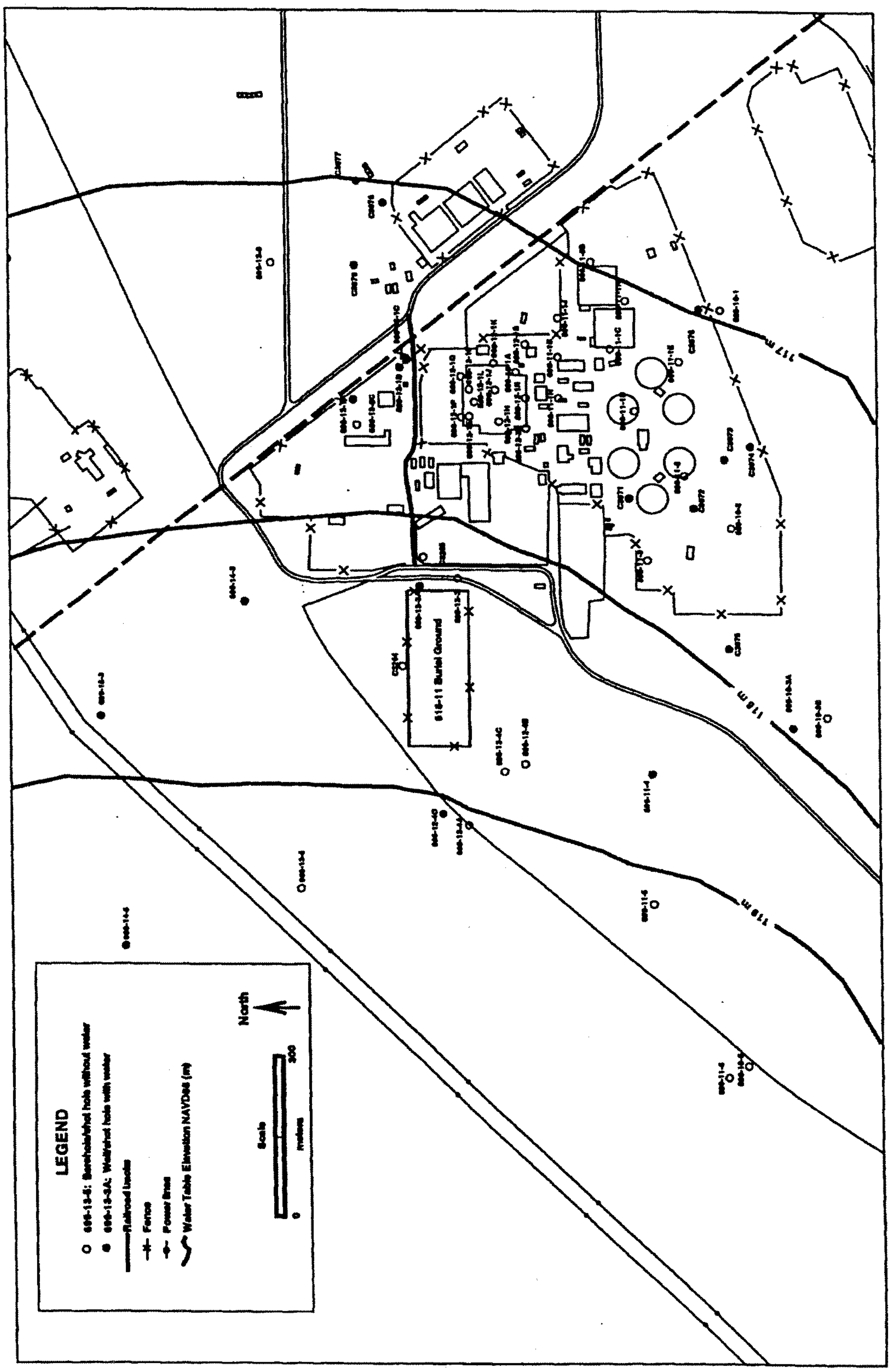


Figure 3-9. Hydrographs from Piezometer Cluster 699-14-E6 in the Vicinity of the 618-11 Burial Ground.

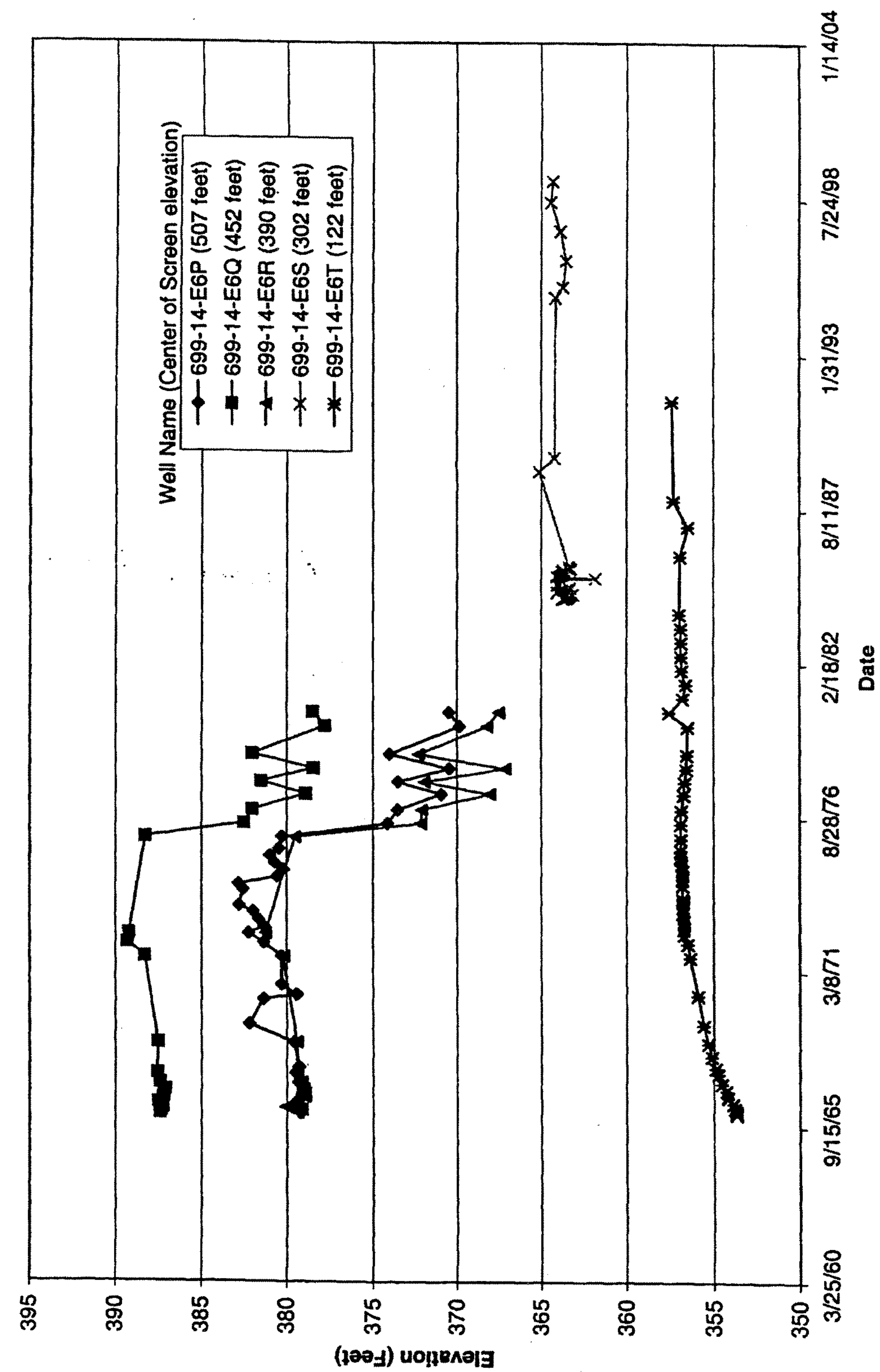


Figure 3-10. Hydrographs from Piezometer Cluster 699-E5-Q, 699-E5-R, and 699-E5-T in the Vicinity of the 618-11 Burial Ground.

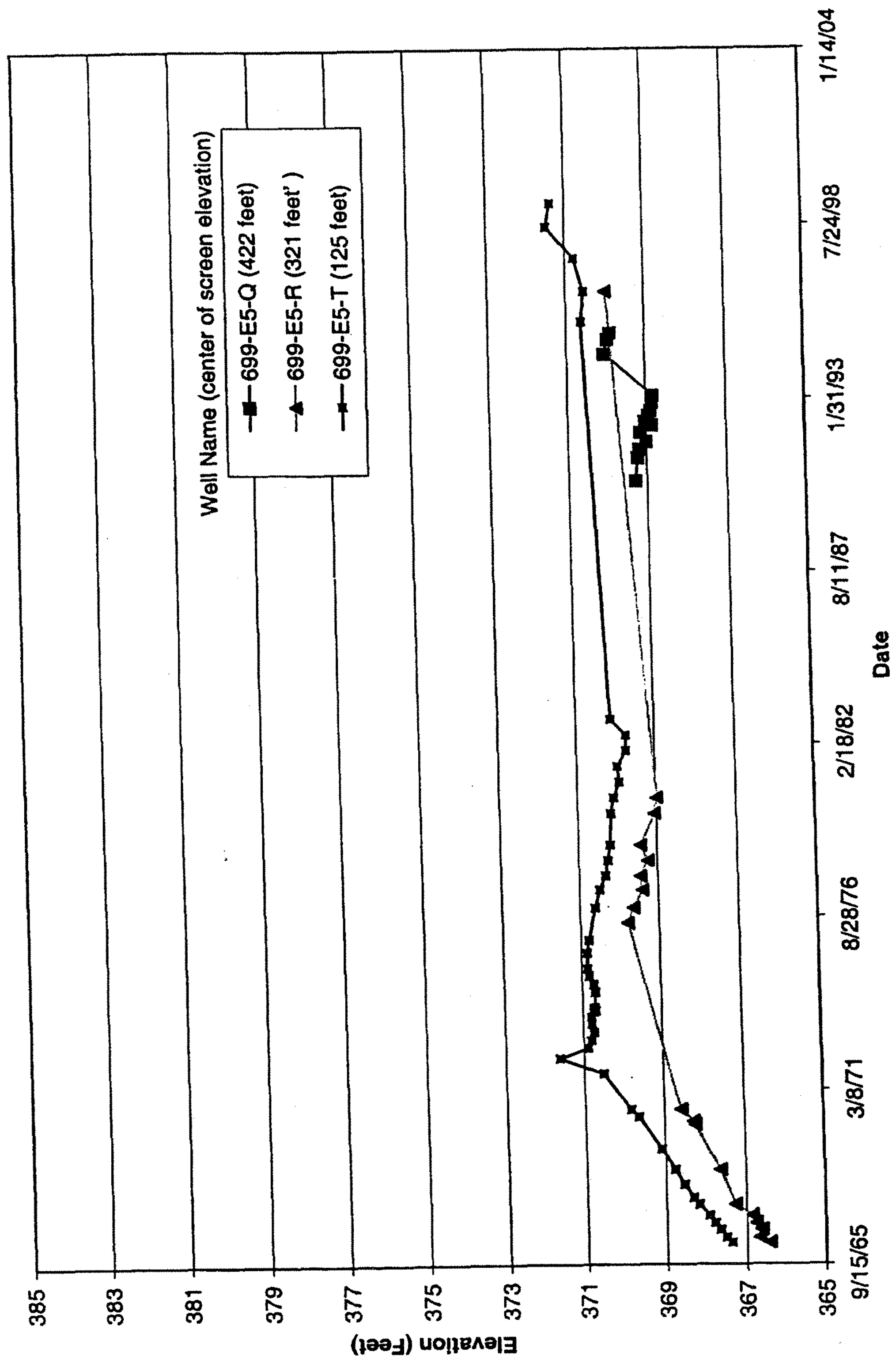
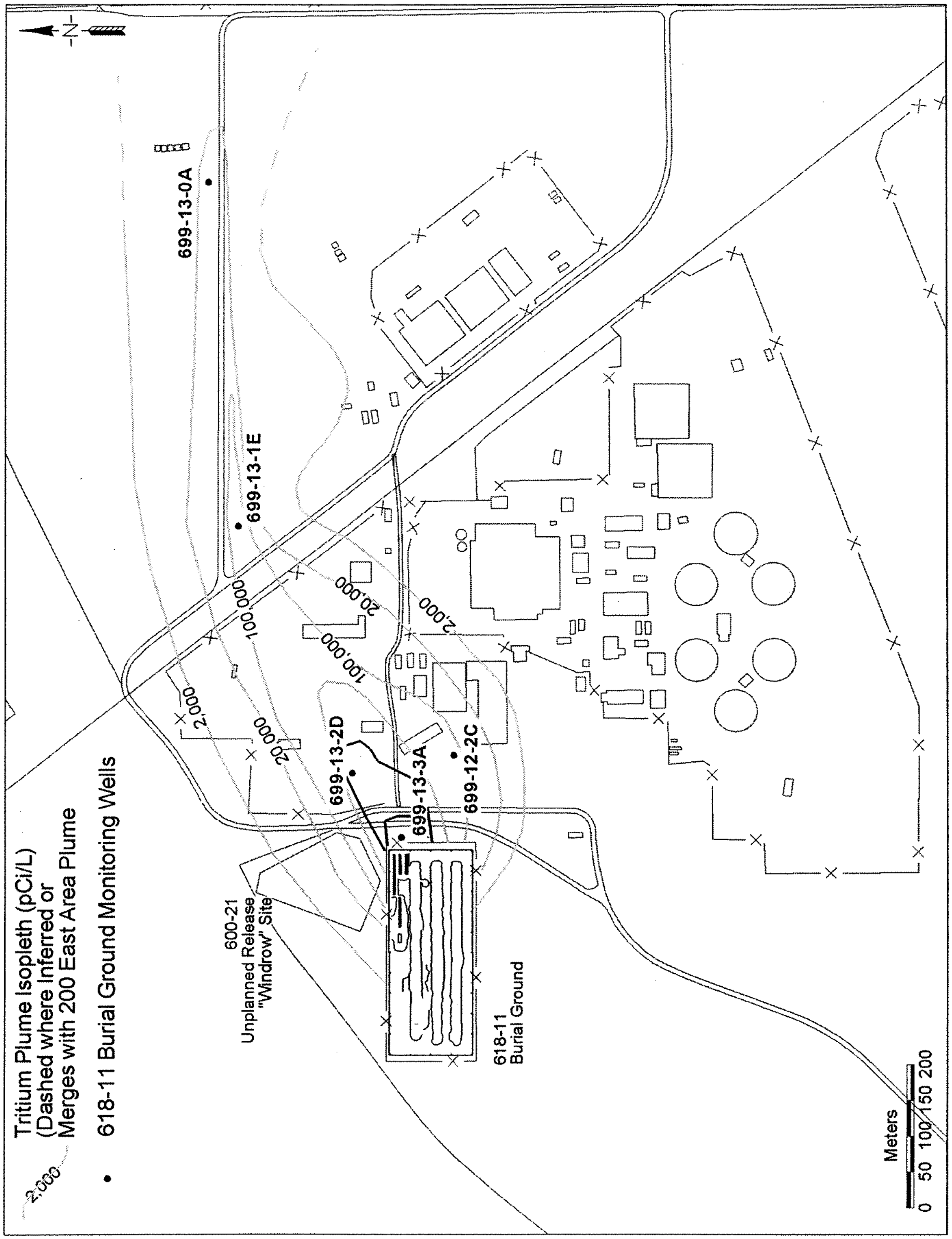


Figure 3-11. 618-11 Burial Ground Tritium Plume[a].



[a] The monitoring well locations indicated are based on preliminary survey data.

Table 3-1. Expected Attenuation Mechanisms for 300-FF-5 Areas of Concern.

300-FF-5 Areas of Concern	COCs	Attenuation Mechanism
300 Area complex	Uranium (total)	Precipitation, adsorption, dilution, dispersion
	Trichloroethylene, dichloroethylene, tetrachloroethylene	Degradation, dilution, dispersion
	Strontium-90	Adsorption, radioactive decay, dilution, dispersion
316-4/ 618-10	Uranium (total)	Adsorption, dilution, dispersion
618-11	Tritium	Radioactive decay, dilution, dispersion

Table 3-2. Radionuclides in 300 Area Clams (1990-1994).

Radionuclide	Median	Mean	Count	Minimum	Maximum
Muscle (pCi/g wet wt)					
Cesium-137[a]	-0.008	-0.007	4	-0.022	0.008
Cobalt-60[a]	0.003	0.004	4	-0.016	0.027
Strontium-90[a]	0.003	0.003	4	0.002	0.003
Shell (pCi/g wet wt)					
Strontium-90	0.275	0.275	1	N/A	N/A

[a] Below or equal to the limit of detection.
N/A = not applicable

Table 3-3. Radionuclides in Fish from the 300 Area (1990-1996).

Radionuclide	Median	Mean	Count	Minimum	Maximum
Carp Fillet (pCi/g wet wt)					
Cesium-137	0.006	0.008	20	-0.005	0.023
Cobalt-60	0.003	0.002	20	-0.033	0.015
Strontium-90	0.001	0.001	20	-0.001	0.003
Carp Offal (pCi/g wet wt)					
Strontium-90	0.027	0.034	20	0.006	0.149
Whitefish Fillet (pCi/g wet wt)					
Cesium-137	0.01	0.011	37	-0.023	0.038
Cobalt-60	0.001	0.001	37	-0.042	0.057
Strontium-90	0.0000	0.0004	32	-0.006	0.008
Whitefish Offal (pCi/g wet wt)					
Strontium-90	0.012	0.013	35	0.004	0.035

Table 3-4. Uranium-238 in 300 Area Shoreline Vegetation at Seep #7 (S1178).

Species	Date	Uranium-238 (pCi/g dry wt)	Analytical Error	MDA
Reed canary grass	01-Jul-99	0.0115	0.0092	0.006
Mulberry	01-Jul-99	0.0647	0.022	0.004
Mulberry	30-Sep-99	0.0314	0.016	0.020

MDA = minimum detectable activity

Table 3-5. Radionuclide Concentrations in 300 Area Vegetation, 1994-1999. (2 Pages)

Date	Radionuclide	pCi/g dry wt	Analytical Error	MDA	Flag-1	Flag-2
Sample Number B0BYX4, Willow from the 300 Area Shoreline						
15-Aug-94	Cs-137	0.0107	0.00981	NR		
15-Aug-94	Co-60	0.015	0.0115	NR		
15-Aug-94	K-40	9.73	1.13	NR		
15-Aug-94	Be-7	1.05	0.243	NR		
15-Aug-94	Ru-106	0.0354	0.0945	NR	U	
15-Aug-94	Cs-134	0.00664	0.0103	NR	U	
15-Aug-94	Zn-65	0.0333	0.0291	NR		
15-Aug-94	Sb-125	0.00849	0.026	NR	U	
15-Aug-94	Eu-155	-0.00198	0.0233	NR	U	
15-Aug-94	Eu-154	0.0195	0.0389	NR	U	
15-Aug-94	CEPR144	-0.0127	0.0962	NR	U	
15-Aug-94	ZRNB-95	0.00262	0.0261	NR	U	
15-Aug-94	Pu-238	-0.00063	0.000715	NR	U	F
15-Aug-94	Pu-239/240	0.000265	0.000286	NR	U	
15-Aug-94	Sr-90	0.0247	0.00761	NR		
15-Aug-94	U-234	-0.00013	0.00238	NR	U	
15-Aug-94	U-235	-2.9E-06	0.00106	NR	U	
15-Aug-94	U-238	0.0016	0.00221	NR	U	
Sample Number B0P9T9, Willow from the 300 Area Shoreline						
02-Sep-98	Cs-137	0.0741	0.0175	NR		
02-Sep-98	Co-60	-0.0117	0.0126	NR	U	
02-Sep-98	K-40	8.25	0.947	NR		
02-Sep-98	Be-7	5.41	0.604	NR		
02-Sep-98	Ru-106	-0.0525	0.077	NR	U	
02-Sep-98	Cs-134	-0.00543	0.00848	NR	U	
02-Sep-98	Sb-125	0.00675	0.026	NR	U	
02-Sep-98	Eu-155	0.0111	0.0224	NR	U	
02-Sep-98	Eu-154	0.0268	0.029	NR	U	
02-Sep-98	Pu-238	0.000048	8.31E-05	NR	U	
02-Sep-98	Pu-239/240	9.12E-05	0.000118	NR	U	
02-Sep-98	Sr-90	0.256	0.0493	NR		
02-Sep-98	U-234	-4.8E-05	0.00711	NR	U	
02-Sep-98	U-235	-0.00066	0.0027	NR	U	
02-Sep-98	U-238	0.00739	0.00821	NR	U	

Table 3-5. Radionuclide Concentrations in 300 Area Vegetation, 1994-1999. (2 Pages)

Date	Radionuclide	pCi/g dry wt	Analytical Error	MDA	Flag-1	Flag-2
Sample Number B0VWV6, Mulberry from the 300 Area at SP-7						
01-Jul-99	Cs-137	0.0081	0.017	0.0306	U	
01-Jul-99	Co-60	0.000749	0.022	0.0382	U	F
01-Jul-99	K-40	18.9	2.1	0.316		
01-Jul-99	Be-7	1.43	0.37	0.314		
01-Jul-99	Ru-106	0.0252	0.16	0.275	U	
01-Jul-99	Cs-134	-0.0303	0.017	0.0265	U	
01-Jul-99	Sb-125	-0.0214	0.04	0.0667	U	
01-Jul-99	Eu-155	0.0208	0.035	0.0628	U	
01-Jul-99	Eu-154	-0.0333	0.07	0.117	U	
01-Jul-99	Sr-90	0.157	0.039	0.0127		
01-Jul-99	Tc-99	1.01	0.27	0.25		
01-Jul-99	U-234	0.0383	0.017	0.0107		
01-Jul-99	U-235	0.00755	0.0075	0.0094	U	
01-Jul-99	U-238	0.0647	0.022	0.00371		
Sample Number B0VWV0, Reed Canary Grass from the 300 Area at SP-7						
01-Jul-99	Cs-137	0.0295	0.022	0.0394	U	
01-Jul-99	Co-60	-0.0111	0.025	0.0426	U	F
01-Jul-99	K-40	19.3	2.2	0.358		
01-Jul-99	Be-7	0.679	0.27	0.476	U	
01-Jul-99	Ru-106	-0.0529	0.19	0.318	U	
01-Jul-99	Cs-134	-0.033	0.022	0.0344	U	
01-Jul-99	Sb-125	0.0347	0.052	0.0907	U	
01-Jul-99	Eu-155	-0.00211	0.052	0.0869	U	
01-Jul-99	Eu-154	-0.0514	0.075	0.123	U	
01-Jul-99	Sr-90	0.0636	0.016	0.00566		
01-Jul-99	Tc-99	0.178	0.22	0.248	U	
01-Jul-99	U-234	0.0202	0.012	0.00973		
01-Jul-99	U-235	-0.00092	0.0029	0.00307	U	
01-Jul-99	U-238	0.0115	0.0092	0.0064	J	
Sample Number B0WKN9, Mulberry from the 300 Area at SP-7						
30-Sep-99	Sr-90	0.129	0.033	0.0133		
30-Sep-99	U-234	0.0328	0.014	0.0108		
30-Sep-99	U-235	0.00417	0.006	0.0103	U	
30-Sep-99	U-238	0.0314	0.016	0.0201		

F = concentration estimated and close to detection
J = estimated quantity
NR = not reported
U = not detected

4.0 PAST ENVIRONMENTAL MONITORING ACTIVITIES

This section is included for completeness and describes the environmental monitoring activities that are planned or in progress in the vicinity of the 300 Area. Some of the sampling and analysis plans schedules described below will be changed as a consequence of new strategies presented in Section 5.0 of this O&M plan.

4.1 GROUNDWATER MONITORING PROGRAMS

All sampling and analysis of groundwater to support program objectives is coordinated through the scheduling database of the Hanford Groundwater Monitoring Project, which is the responsibility of PNNL. In addition to tracking the numerous schedules for wells and analyses associated with a variety of projects, the scheduling database provides a mechanism to integrate field activities and avoid duplication of effort. An integrated schedule and Hanford Groundwater Monitoring Project summary is prepared annually to show current use of monitoring wells by the various programs (Hartman et al. 2001). The following sections provide an overview of the various groundwater monitoring programs.

4.1.1 CERCLA: 300-FF-5 Long-Term Monitoring

As initially defined in the 1996 ROD (EPA 1996), groundwater monitoring for the 300-FF-5 OU includes nine 300 Area wells that are sampled annually. The purpose of the monitoring is to ensure that contaminant concentrations in areas where health-based levels are exceeded continue to decrease with time.

In FY 2000, the geographic area covered by the 300-FF-5 OU was expanded to include the groundwater beneath the 618-10 and 618-11 Burial Grounds (EPA 2000). Two additional wells are sampled semiannually at the burial grounds to provide an improved characterization of groundwater contamination associated with those waste sites. Four new wells were installed in FY 2001 to monitor the tritium in groundwater associated with the 618-11 Burial Ground. Several new wells are planned to provide additional monitoring capability at the 618-10 Burial Ground.

4.1.2 RCRA: 300 Area Process Trenches

Eleven wells are monitored on quarterly or semiannual schedules to support final-status corrective action monitoring of the 300 Area Process Trenches (Lindberg and Chou 2001). The objective is to confirm that levels of COCs are decreasing with time and to determine whether groundwater beneath the former trenches is in compliance with gorundwater protection standards. Prior to 2001, groundwater monitoring was conducted under a compliance groundwater monitoring plan (Lindberg et al. 1995). The changes to the monitoring was an addition of 5 wells to the network to fully characterize the plumes of uranium and volatile organics, the deletion of two upgradient wells from the network, and the use of the Combined

Shewhart-CUSUM control chart statistical analysis method. This method is an intra-well method to track the contaminant concentration trend with time.

4.1.3 *Atomic Energy Act* Environmental Surveillance

As part of environmental surveillance activities under DOE Order 5400.1 (DOE-RL 2000a), 30 wells in the vicinity of the 300-FF-5 OU are monitored on an annual-to-semiannual basis. Surveillance activities are frequently performed as co-sampling events with CERCLA and RCRA program sampling. Additional analyses are performed to complement the data gathered under the CERCLA and RCRA programs. Surveillance monitoring is typically conducted to track plumes that have migrated a considerable distance from their waste site sources.

4.1.4 Washington Department of Health Oversight

The Washington State Department of Health (DOH) conducts groundwater and surface water sampling (through their environmental radiation program) to provide oversight of Hanford Site environmental monitoring activities. Analysis of their samples is conducted by independent laboratories not routinely used by Hanford Site contractors. Actual sampling is sometimes conducted as a co-sampling event with other programs.

4.2 GROUNDWATER/RIVER INTERFACE MONITORING PROJECTS

Several field methods are available and in use at the Hanford Site to monitor contamination carried by groundwater to the interface with the Columbia River. To obtain groundwater samples from the aquifer close to the river channel, aquifer sampling tubes have been installed at multiple depths near the low-river stage shoreline in the 100 Areas (BHI 1998b). Samples of riverbank seepage are collected to determine the level of contamination in surface water exposed along the beach during low-river stage. River water is collected along the shoreline and along transects across the river. Finally, aquatic biota and shoreline vegetation samples are obtained to determine if contaminants are entering the food chain.

4.2.1 CERCLA: Aquifer Sampling Tube Project and Riverbank Seepage

Aquifer sampling tubes have not yet been installed along the entire 300 Area river shoreline. Tubes installed along the 100 Area shoreline in 1997 are sampled annually. The tubes produce high-quality data on selected constituents of concern at locations very close to the point of discharge into the riverbed interface (Raidl 2001). The methodology has high potential for use along the 300-FF-5 OU river interface.

Riverbank seepage samples are collected annually during the fall seasonal low-river discharge period to support long-term monitoring of groundwater OUs. Where exposed, seepage is collected during co-sampling with the Surface Environmental Surveillance Project (SESP).

4.2.2 DOE Order 5400: Surface Environmental Surveillance Project

As part of environmental surveillance activities under DOE Order 5400.1 (DOE-RL 2000a), annual water samples are collected from two riverbank seepage sites, five near-shore river water locations, and five locations on a cross-river transect. In addition, sediment is collected from two riverbank seepage sites on an annual basis. These water and sediment samples are analyzed for both radiological and chemical contamination indicators.

Soil and perennial vegetation samples are periodically sampled by the surveillance project along portions of the shoreline in areas of potential radiological contamination, and also in areas assumed to be free of contamination to provide baseline levels. The shoreline adjacent to the 300 Area has been included in the sampling. Mulberry tree and reed canary grass are typical species collected, with analysis of the samples for gamma-emitting radionuclides, tritium, strontium-90, technetium-99, and uranium isotopes. At some locations, drive-point methodology is used to obtain moisture samples from the root zone of vegetation.

The results of environmental surveillance monitoring along the Columbia River shoreline adjacent to Hanford Site facilities are published in the annual Hanford Site environmental monitoring report (PNNL 2001a).

4.3 COOPERATIVE BIOTA INVESTIGATION

During August 2001, a cooperative field investigation was conducted by PNNL's SESP and the DOH. The combined team collected and analyzed samples of river water, near-river groundwater, riverbank seepage, aquatic biota, and riparian biota. Measurements of external radiation levels were included as part of the shoreline monitoring study.

Table 4-1 lists the locations where biota samples were collected during the survey. Riverbank seepage has been observed previously at these locations; several of these seepage sites are routinely monitored for contamination indicators (i.e., sites listed as spring #7 and #9 [S1178 and S1180, respectively]). In addition to biota samples, sediment samples were collected from each seepage site, and water was sampled at all locations where biota samples were collected. Analyses for tritium and uranium were performed on each water sample, along with additional contamination indicators at selected locations. Aquifer sampling tubes were installed at spring locations #7 and #9 (S1178 and S1180, respectively). Tubes were driven to several depths in the aquifer, along transects that extended offshore from the shoreline seepage sites. These installations were designed to allow resampling of the aquifer during periods of high-river stage. The sample locations and biota collected for this August 2001 event are summarized in Table 4-2. The results of this investigation will be reported in early 2002.

Table 4-1. 300 Area Seep/River Sample Locations (August 2001).

Sample Location	Perpendicular Distance From Shore (m)				
	Shoreline[a]	0.24-m Depth	0.5-m Depth	1.0-m Depth	1.5-m Depth
Spr-7 (S1178)	0	3.48	9.4	12.0	15.3
DR 7[b]	NS[c]	<0.5	2.1	7.6	9.9
Spr-9 (S1180)	0	1.6	4.6	9.8	15.6
DR 9[d]	NS[c]	<0.5	1.8	8.5	12.9
Spr-11 (S1182)	NS[c]	<0.5	2.0	3.2	6.3
Spr-14 (S1185)	NS[c]	<0.5	2.8	3.6	6.8

NOTE: Columbia River discharge was about 1,133 m^3/sec (40,000 ft^3/sec).
[a] Shoreline locations are identified on well location map presented in Appendix B.
[b] Transect was about 130 m (426 ft) downstream from the seep location.
[c] No seep present; no sample was collected at the shoreline.
[d] Transect was about 45 m (147 ft) downstream from the seep location.
NS = no sample

Table 4-2. 300 Area Seep Biota Sampling Summary (August 2001).

Biota	Vernita	Location 7 (S1178)	Location 9 (S1180)	Location 11 (S1182)	Location 14 (S1185)
Terrestrial Species					
House mouse		√		√	√
Darkling beetles	√	√	√	√	√
Mayflies (adult)	√	√	√	√	√
Sweet clover	√	√	√	√	√
Mulberry tree leaves	√	√	√	√	√
Aquatic Species					
Crayfish	√	√	√	√	√
Prickly sculpin	√	√		√	√
Asian clam	√	√	√	√	√
Periphyton	√	√	√	√	

√ = Species sampled from this location.

5.0 300-FF-5 MONITORING AND REMEDIAL ACTION EVALUATION APPROACH

In the *USDOE Hanford Site First Five Year Review Report* (EPA 2001c), action item 300-4 states that this revised O&M plan needs to include "requirements for evaluation of groundwater data including an assessment of the effectiveness of the natural attenuation remedy." This section describes the strategy for evaluating the natural attenuation processes for the COCs in 300-FF-5 OU groundwater. The principal challenges are as follows:

- Identify the natural processes responsible for reducing contaminant mass, concentration, extent, mobility, and/or toxicity
- Establish the relative importance of the natural processes identified for each constituent of concern
- Identify the data, information, and analyses required to assess MNA effectiveness and the time frame for compliance with water standards (i.e., drinking water MCLs and ambient water quality criteria [AWQC])
- Develop a model that describes the rate/location of contaminant recharge, mass and volume in the aquifer, and rate/location of discharge from the aquifer at the groundwater/river interface
- Design an environmental monitoring schedule that will provide timely data for evaluating the rate and effectiveness of natural attenuation.

5.1 SELECTED REMEDY

The ROD and subsequent ESD for the 300-FF-5 OU pertain to interim remedial actions (EPA 1996, 2000) that involve imposing restrictions on the use of the groundwater until such time as health-based criteria are met through natural attenuation for the COCs in the 300-FF-5 OU. The interim remedy includes the following:

- Continued monitoring of groundwater that is contaminated above health-based levels to ensure that concentrations continue to decrease
- Institutional controls to ensure that groundwater use is restricted to prevent unacceptable exposure to groundwater contamination.

Continued groundwater monitoring, modeling, and studies identified in this O&M plan will be used to verify predictions of contaminant attenuation as supported in the ROD. The monitoring is intended to identify whether attenuation is occurring in a manner consistent with the EPA guidelines (EPA 1999). The 1993 numerical model predictions (DOE-RL 1994) indicated that RAOs for uranium would be attained in 3 to 10 years (i.e., 1996 to 2003).

As stated in the ROD, the RAOs are as follows:

1. Protect human and ecological receptors from exposure to contaminants in soils and debris by exposure, inhalation, or ingestion of radionuclides, metals, or organics.

2. Protect human and ecological receptors from exposure to contaminants in the groundwater and control the sources of groundwater contamination in 300-FF-1 to minimize future impacts to groundwater resources.

3. Protect the Columbia River so that contaminants in the groundwater or remaining in the soil after remediation do not result in an impact to the Columbia River that could exceed the Washington State surface water quality standards.

Because no active manipulation of contaminants in the aquifer is required by the ROD, nor is any under way, reducing the supply of contaminants to the aquifer is the only active remediation effort in progress. Source control is being achieved by removing contaminated vadose zone soils at waste sites. Natural mitigating processes in the vadose zone, groundwater, and river systems are being relied upon to protect the Columbia River. Identifying and quantifying the rates of those processes are essential elements of the strategy in order to evaluate the effectiveness of the interim remedial action approach (i.e., MNA). If monitoring does not confirm the predicted decrease of contaminant levels, DOE and EPA will reevaluate the selected interim action remedy.

5.2 U.S. ENVIRONMENTAL PROTECTION AGENCY GUIDANCE FOR MONITORED NATURAL ATTENUATION

Data-gathering activities and the evaluation of the effectiveness of MNA will follow EPA natural attenuation guidelines (EPA 1999). The EPA outlined a three-tiered approach for assessing the effectiveness of remedial actions in this guidance. The MNA would be shown to be effective if the following conditions are observed:

1. Historical groundwater and/or soil chemistry data demonstrate a clear and meaningful trend of decreasing contaminant mass and/or concentration over time at appropriate monitoring or sampling points. For groundwater plumes, decreases in concentration should not be due solely to plume migration. For inorganic contaminants, the primary attenuating mechanism should be understood.

2. Hydrogeologic and geochemical data demonstrate the type(s) of natural attenuation processes active at the site and the rate at which such processes will reduce contaminant concentrations to required levels. For example, characterization data may be used to quantify the rates of

contaminant sorption, dilution, or volatilization, or to demonstrate and quantify biological degradation rates at the site.

3. Data from field or microcosm studies (conducted in or with contaminated site media) demonstrate the occurrence of a particular natural attenuation process at the site and its ability to degrade the COCs. This approach is typically used to demonstrate biological degradation processes.

The guidance states that if the data from item 1 are insufficient to evaluate a remedial action, then data from item 2 will also be required. If the data from item 2 are not adequate, data from item 3 may also be required. This O&M plan assumes that data will be required for both tiers 1 and 2 of the EPA guidance to establish the efficacy of MNA for the 300-FF-5 groundwater plumes.

EPA MNA guidelines (EPA 1999) also address performance monitoring guidance to be implemented during the period of attenuation. The EPA states that the monitoring program should specify the "location, frequency, and type of samples and measurements necessary to evaluate whether the remedy is performing as expected and is capable of attaining remediation objectives." In addition, the guidance states that the monitoring program should be designed to accomplish the following:

- Demonstrate that natural attenuation is occurring according to expectations
- Detect changes in environmental conditions (e.g., hydrogeologic, geochemical, microbiological, or other changes) that may reduce the efficacy of any of the natural attenuation processes
- Identify any potentially toxic and/or mobile transformation products
- Verify that the plume(s) is not expanding (either downgradient, laterally, or vertically)
- Verify no unacceptable impact to downgradient receptors
- Detect new releases of contaminants to the environment that could impact the effectiveness of the natural attenuation remedy
- Demonstrate the efficacy of institutional controls that were put in place to protect potential receptors
- Verify attainment of remediation objectives
- Enable a determination of the rate(s) of attenuation and how that rate is changing with time.

5.3 GROUNDWATER MONITORING

There is significant overlap between the RCRA corrective action program and the CERCLA program in the 300 Area. Some 300 Area waste sites are subject to possible remediation under both programs. According to the 1999 annual report (PNNL 2000b), groundwater samples collected from monitoring wells in the 300 Area were analyzed for a variety of dangerous waste constituents and site-specific constituents, including selected radionuclides. The constituent lists meet the minimum RCRA regulatory requirements and are integrated to supplement other groundwater project requirements (e.g., CERCLA) at the Hanford Site. The path for resolution of inconsistencies between the programs is being addressed by EPA and Ecology. Groundwater sampling and analysis will also be coordinated with the sitewide surveillance monitoring program.

All groundwater samples monitored for the CERCLA program should include depth-to-groundwater measurements and field parameters. Depth-to-groundwater measurements and field parameters (e.g., pH, temperature, reduction-oxidation potential, dissolved oxygen, and conductivity) should also be obtained from wells monitored under the RCRA and sitewide programs.

Wells constructed prior to 1986 (when WAC 173-160 was put into effect) do not meet current construction or design requirements. These wells are still expected to provide sufficiently representative data for evaluating water quality. For more recent projects, such as closure of the 300 Area Process Trenches, WAC 173-160-compliant wells have been constructed and are used to demonstrate compliance.

The primary purpose for environmental monitoring activities described in this O&M plan is to provide observational data on contaminant levels in groundwater and at the groundwater interface with the Columbia River. These data will be used to characterize natural attenuation process rates and to determine contaminant levels and trends with time. Key parameters include (1) the areal extent and volume of contaminated groundwater, (2) the mass of contaminants in the plumes, and (3) concentration trends at monitoring locations. The data will also be used to calibrate numerical models and verify the output from the models. This section presents a summary of the groundwater monitoring plan, which is based on the DQO summary report presented in Appendix A.

5.3.1 300-FF-5 Monitoring Wells

Table 5-1 lists all available wells in the 300-FF-5 OU, their dates of depths of completion, the program under which they are currently being sampled, their position relative to COC plumes, and the reason for being included or excluded from the schedule presented in this plan. Table 5-1 also indicates if the well is a key indicator well or a sentry well. A key indicator well is one that is generally located close to the suspected sources of the 300-FF-5 contaminant plumes and provides key information regarding near-field plume conditions. A sentry well monitors conditions at a greater distance from a facility or waste site than key wells, is generally located near the downgradient boundaries of the 300-FF-5 contaminant plumes, provides information regarding far-field plume conditions, and is used to determine the concentration gradients in plumes extending from a source and the areal extent of plumes. Wells near waste sites that may show contamination in the future or have shown contamination in the past (but not at the current time) are considered sentry wells.

The selection of groundwater monitoring wells to determine flow characteristics and water quality characteristics in the 300-FF-5 OU is based on previous detection of COCs above drinking water MCLs, known COC source locations, and position relative to currently inferred plume boundaries. Table 5-2 shows the wells selected during the DQO process (Appendix A) to support the objectives stated in this plan. The table lists the sampling frequency, the areas of concern that each well monitors, and the suite of analyses for samples collected. The wells and constituents monitored will be reevaluated as new results are obtained and the schedule modified to adapt to new information, as appropriate. Well locations in the 300 Area are shown in Appendix B, Figure B-2. The well names and their location with respect to the plumes are also shown in Appendix B figures.

5.3.2 Groundwater Schedule

Groundwater samples will be collected semiannually or annually, depending on the area of concern. Wells in the 300-FF-1 and 300-FF-2 geographic area (generally east of Route 4) will be sampled semiannually, during high (spring) and low (summer/fall) Columbia River flow periods, to track the influence of the river stage on groundwater contamination concentrations. Monitoring wells not influenced by the Columbia River (generally west of Route 4) will be sampled annually. The 618-11 and 618-10/316-4 areas are not influenced by Columbia River flows, but should still be sampled semiannually for at least the first year to establish water quality baseline. Sampling should be coordinated with RCRA activities in the 300 Area to provide a consistent and cost-effective approach to sampling. Groundwater monitoring will continue until the effectiveness of MNA is reviewed in 5 years and/or remedial goals are met.

5.4 GROUNDWATER/RIVER INTERFACE MONITORING

This section presents the recommended strategy to monitor contamination levels at various locations along the groundwater interface with the Columbia River. The media to be sampled includes groundwater from aquifer sampling tubes installed at the shoreline, riverbank seepage, seep-associated sediment, and river water associated with the seeps.

The objective of this monitoring effort is to characterize near-shore radiological and chemical conditions when river conditions would not likely influence contaminant concentrations.

5.4.1 Shoreline Aquifer Sampling Tube Monitoring

Aquifer tubes are small-diameter (0.63 cm [0.25 in]) tubes with screened openings that are installed by driving a temporary steel casing into the aquifer, using either a hand-carried air hammer or a Geoprobe® unit (BHI 1997b). Tubes are typically installed at multiple depths in the aquifer at each location to obtain data on the vertical distribution of contaminants. The methodology has been successfully used to support groundwater OU data needs along the Hanford Reach shoreline from the 100-B Area downstream to the Hanford townsite (BHI 1998b, Raidl 2001). Similar drive-points were installed adjacent to seeps S1178 and S1180 in the 300 Area in August 2001. New aquifer tubes would be installed (as appropriate) to provide additional areal coverage of groundwater plumes near the groundwater/river interface. The installations will be designed to allow sampling during all river stage conditions, thus providing new data on seasonal variability.

5.4.2 Riverbank Seepage Monitoring

Seeps along the 300 Area river shoreline will be sampled (water and sediment) and analyzed for selected COCs. Sampling areas will include seeps S1178 and S1180 that were previously sampled for the 300-FF-5 OU (see Appendix B, Figure B-10). Global positioning system coordinates will identify all sampling locations. Table 5-3 presents a comparison of old and new seep and river monitoring site names. The seep water and sediment will initially be analyzed for VOAs (including dichloroethylene, trichloroethylene, vinyl chloride, and tetrachloroethylene), uranium, strontium-90, and anions (including nitrate). If specific COCs are not detected in seep water or sediment, analysis for those COCs may be discontinued (with EPA approval) after the first year of sampling.

5.4.3 Columbia River Monitoring

River water and sediment sampling will be conducted to determine the effect of groundwater seeps on the Columbia River quality in localized areas. Columbia River water sampling will follow the schedule for seep water sampling (see Section 4.2.1). The river water will initially be analyzed for VOAs and degradation products (including dichloroethylene, trichloroethylene, tetrachloroethylene, and vinyl chloride), uranium, strontium-90, and anions (including nitrate). If specific COCs are not detected in river water, additional sampling for those COCs may be discontinued (with EPA approval) after the first year of sampling.

Changes in the elevation of the Columbia River will be monitored with a river stage recorder. Measurements will be used to document river stage during sampling and analysis activities and provide input to evaluate river and groundwater interaction. River stage monitoring will be performed in accordance with WHC (1992a).

5.4.4 River Interface Schedule

Near-shore seeps, seep-associated sediment, and seep-associated river water will be monitored annually during Columbia River low flow (e.g., August or September). Aquifer tubes will be monitored annually (during low-river stages) to establish seasonal water quality conditions.

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5.5 BIOTA MONITORING

The PNNL and DOH performed a joint study on the 300 Area seep-associated biota in August 2001. The preliminary results from this study form the technical basis for establishing what locations and organisms should be used for long-term monitoring.

5.5.1 Biota Monitoring Requirements

Biota should be monitored near two seeps (S1178 and S1180). Global positioning system coordinates will identify sampling locations. The recommended sample locations roughly correspond to historical sample locations described in the *Sampling and Analysis of 300-FF-5 Operable Unit Springs and Near-Shore Sediments and River Water* (WHC 1993b) (Table 5-3). Upland biota (within 20 m [65 ft] of the high-water mark) and aquatic biota will be collected if sufficient biota are present (Table 5-4). The seep-associated biota will be initially analyzed for uranium, and strontium-90. If specific COCs are not detected in biota, additional analysis for those COCs may be discontinued (with EPA approval) after the first year of sampling.

5.5.2 Biota Schedule

Seep-associated biota will be monitored during Columbia River low-flow periods (i.e., August or September).

5.6 GROUNDWATER MODELING

The groundwater modeling component of the strategy presented in this O&M plan integrates existing and new hydrologic and contaminant transport information into a comprehensive data analysis capability. The modeling capability provides for the following:

- Evaluation of key components of the conceptual model for the flow system and contaminant-specific transport parameters as they relate to natural attenuation

- Examination of overall system performance to determine if and when compliance with remedial action goals may be achieved for all contaminant plumes identified in this O&M plan.

As remediation of liquid waste disposal sites is completed, various amounts of uranium and other contaminants may remain in the vadose zone in the vicinity of waste site footprints. Some of this contamination will likely remain fixed in the vadose zone because of sorption processes, and some will likely continue a slow, downward migration toward groundwater. Release to groundwater will occur at the capillary fringe interface. Knowledge of the locations and a general understanding of the rates of release are important parameters for determining the natural attenuation trend of contaminant plumes over time and for predicting future conditions via numerical models.

Groundwater movement and contaminant fate and transport in the 300-FF-5 OU were previously modeled as part of the 300-FF-5 Phase I remedial investigation and 300-FF-5 RI/FS (DOE-RL 1994) using the PORFLO computer code (WHC 1992c). Groundwater modeling was used to predict the concentrations of various COCs for the year 2018. Based on 1994 data and information, 2018 was chosen as the year when institutional controls could be removed from the 300 Area site and additional uses of the aquifer could occur. The COCs evaluated were derived from a list of contaminants previously detected in the groundwater beneath the 300 Area, using risk-based screening. The results of the risk analysis indicated that uranium posed the largest risk to human health.

The principal limitations associated with the remedial investigation fate and transport modeling included the assumption of no continued source for COC input to groundwater and soil characteristics for only one of the surface OUs (i.e., 300-FF-1). Future modeling efforts are intended to provide more reliable predictions because of the availability of new and/or updated information on these important components of modeling. For example, source inventories, plume maps, and hydrogeologic characterizations have all improved since the remedial investigation was developed in 1994. Parameters such as partitioning coefficients and hydraulic conductivity need further refinements to provide more credible model simulations. The interaction between groundwater and the river is better understood (Peterson and Connelly 2001).

Fate and transport modeling provides a means to substantiate various aspects of the conceptual models for contaminant movement and attenuation within the 300-FF-5 OU groundwater system. Numerical modeling is also useful for evaluating the time and resources necessary to establish a technical basis for a final remediation strategy. Modeling can contribute to determining the following:

- Whether current or predicted future contamination levels pose unacceptable risk to human health or the ecological community
- Whether contaminants in the environment are recharging existing plumes
- Whether contaminants in the environment may result in new plumes
- Whether the perimeter of existing plumes may expand, contract, or remain static
- Relative criteria for evaluating remediation strategies.

Numerical models proposed for helping to evaluate the degree of natural attenuation that is occurring within the OU will involve data and information related to local-scale groundwater and vadose zone conditions, and dynamic interactions with the Columbia River. The objectives will be addressed using selected multi-dimensional subregional scale and cross-section scale modeling codes that are designed to address specific aspects of the current conceptual model for groundwater movement and contaminant transport.

5.6.1 Subregional Scale Modeling

During the initial implementation of this revised 300-FF-5 O&M plan, a subregional scale model for groundwater movement beneath the 300 Area will be developed. The scale model will be similar in scope and domain to the previous model that used the PORFLO code (WHC 1992c). Key parameters associated with hydraulic and transport properties for various COCs will be critically evaluated against new data and information that has been collected since the time of the previous analysis. The primary purpose for the initial modeling effort is to establish the hydrogeologic framework, and the direction and rate of flow within the groundwater system.

The model will focus initially on simulating subregional flow conditions in the 300-FF-5 area, based on local-scale information supplemented with other relevant regional-scale information. Model boundary conditions and hydraulic properties in areas with limited data will be developed where appropriate. This can be accomplished by evaluating data and information associated with regional-scale interpretations of hydrogeologic framework and with directions and groundwater flow rates that are simulated within the 300-FF-5 domain in the Hanford Site regional-scale model. Confidence in the subregional model will be established through calibration of the model to historical measurements of hydraulic head within the region of interest.

Once the flow conditions are established in the subregional scale model, it can be used to evaluate important technical issues and processes for the target constituents of concern. The model can provide the basis for more detailed site-specific information needs within the 300-FF-5 area. The first evaluation will be focused on technical issues related to uranium contamination in the 300 Area. Key objectives include establishing the temporal variability for model parameters and determining the important natural attenuation processes/parameters that cause the contaminant plume to change with time. This assessment will be founded on (1) a three-dimensional spatial representation of the contaminated hydrologic unit(s), (2) the best available information on the direction and gradients at the water table, and (3) the distribution of the contaminant as indicated by analytical results for groundwater samples.

The model will be used to estimate the areal extent, volume of groundwater contaminated, and mass of the contaminant in the plume. Estimates will be prepared using historical data so that the progression of trends over time for these parameters can be determined. This effort addresses the first of three tiers described in the EPA guidance for demonstrating the efficacy of natural attenuation as a remedy (EPA 1999, pp. 13-16). Once confidence has been established with the ability of the subregional model to approximate historical contaminant plume behavior, forward predictions of contaminant plume will be made to evaluate the near-term and long-term behavior and persistence of the contaminant plume in areas where it is currently above regulatory limits.

5.6.2 Cross-Sectional Scale Modeling (Two-Dimensional)

Flow paths followed by a parcel of water as it moves from the aquifer, through the zone of groundwater/river interaction, and into the free-flowing stream of the Columbia River will be modeled using well-established codes. Previous experience at the Hanford Site with this type of modeling includes an analysis of flow at the 100-N and 100-H Areas (Peterson and Connelly 2001). A two-dimensional representation of water movement in the zone of interaction as the river stage rises and falls reveals the dimensions of the zone influenced by infiltrating river water and where discharge from the aquifer may be focused on the riverbed. This information is used for designing monitoring networks and for identifying locations with the greatest potential for exposure to contaminated groundwater.

A high-resolution, two-dimensional flow and transport model that can accommodate a fluctuating river boundary will be developed for a representative 300 Area profile, oriented perpendicular to the river and including a portion of the river channel. The model will be based on an appropriate saturated/unsaturated zone code (e.g., Surface Transport Over Multiple Phases [STOMP] finite difference code previously used at the Hanford Site) that facilitates addressing issues related to the influence of the fluctuating Columbia River stage on flow and contaminant transport in the near-river environment.

Again, the first evaluation will be focused on uranium. The purpose of this modeling is to evaluate the current understanding of the location, timing, rate of release of contamination from the vadose zone underlying the footprints of waste sites, and desorption of the contaminant from the vadose zone in the near-river environment. These processes are currently being assessed in an ongoing uranium K_d/leachability study and may become key aspects for demonstrating the rate of natural attenuation in the groundwater system. The release of the contaminant from the vadose zone beneath waste disposal sites can be modeled, and the resulting information would help to understand source term release processes. This ultimately contributes to a more credible subregional scale model for groundwater flow and transport of the contaminant. Multiple cross-sectional models may be required to accommodate the heterogeneity in hydrogeologic conditions and multiple COCs.

5.6.3 Modeling for Waste Site Closeout

The remediation process for waste sites in the vadose zone requires an evaluation of the potential for residual contamination remaining in the soil to impact groundwater by leaching and causing contaminant groundwater concentrations above drinking water standards (e.g., MCLs). At the Hanford Site this modeling has been performed by using the one-dimensional transport model included in the RESidual RADioactivity (RESRAD) software developed by Argonne National Laboratory (ANL 1994). The RESRAD model of dose to a receptor provides the means to evaluate pathways for direct exposure to gamma radiation, inhalation of dust, ingestion of soil, and pathways for the ingestion of food and drinking water. The general evaluation of the potential for radionuclides to be transported to groundwater involves the use of input parameters that have been determined to be applicable to the contaminated zone, an uncontaminated unsaturated zone in the vadose zone beneath the contaminated zone, and the saturated zone (groundwater). The vertical extent of each of these zones is evaluated, as necessary, during the preparation of a cleanup verification package (CVP) for individual waste sites. The generic site model for evaluation of waste sites with general contaminants is described in Figure 5-1. The CVP process is described in detail in Appendix B of the *Remedial Design Report/Remedial*

Action Work Plan for the 300 Area (DOE-RL 2002a) and will continue to be used in the future for waste site closeout.

The RESRAD evaluation for cleanup verification normally uses a single K_d value to characterize contaminant transport in the contaminated, uncontaminated, unsaturated, and saturated zones. This single K_d value for all zones is based on the propensity for contaminants to adsorb from water onto solids. While a single K_d value may be adequate to describe the transport phenomena for most contaminants, it has proven inadequate to describe uranium transport from the vadose zone to groundwater.

The primary natural attenuation and transport mechanisms associated with uranium in the 300 Area are likely dilution, dispersion, adsorption, and desorption of uranium in groundwater, vadose zone soil, and saturated zone soil. The preliminary results of the uranium K_d/leachability study, as described in the *Sampling and Analysis Plan for the 300 Area Uranium Leach/Kd Study* (DOE-RL 2002b), indicate that there is a readily leachable fraction of uranium and a less leachable fraction of uranium present in soil affected by past waste disposal. Current knowledge of this phenomenon is described in the preliminary uranium soil-to-groundwater conceptual site model pictured in Figure 5-2. The study is being performed to support soil remediation projects and therefore uses near-source vadose zone soil collected from waste sites. However, the characteristic of a readily leachable and less leachable fraction of uranium in soil is likely applicable to saturated zone soil affected by past waste disposal as well. The seasonal fluctuation of uranium groundwater concentrations is supportive of this concept and is likely the result of the seasonal fluctuation of river levels. When the river level rises, raising groundwater levels, the readily leachable fraction of uranium is desorbed or leached from the seasonally saturated lower vadose zone soil into groundwater, and the seasonal uranium groundwater concentration peak occurs. Because the saturated zone soil is always saturated, the readily leachable fraction of uranium in the saturated zone is likely in equilibrium with the uranium in aquifer sediments. As the continuing river level/groundwater level seasonal variation continues, the readily leachable fraction of uranium in this seasonally saturated zone should be reduced, and the seasonal variation of uranium groundwater concentrations should attenuate. That is, the seasonal high uranium groundwater concentration will still occur, but the differences between seasonal concentrations will not be as pronounced. The less leachable fraction of uranium in saturated zone soils will continue to slowly desorb from the saturated zone soil into groundwater over an extended period of time. The uranium K_d/leachability study is continuing and will provide additional understanding of uranium mobility and attenuation potential. The impacts of the study results on the understanding of MNA will be evaluated in future PNNL annual groundwater reports.

5.7 MONITORED NATURAL ATTENUATION EFFECTIVENESS EVALUATION

Evidence of MNA effectiveness will be developed through a variety of approaches (i.e., groundwater and seep contaminant-level trends over time, seep/biota contaminant levels, water quality criteria comparisons, and numerical modeling). These approaches are summarized in Table 5-5. The following sections discuss key evaluations that should be included in the annual 300-FF-5 monitoring reports so that decisions regarding MNA effectiveness, the need for additional remedial actions, ACLs for groundwater, and technical impracticability can be included in the FY 2005 EPA CERCLA 5-year review.

5.7.1 Near-Shore Source Removal Influence on Groundwater Quality

The directive *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites* (EPA 1999) calls for source control measures to be evaluated and used for all contaminated sites, if practicable. The remove-treat-dispose remedy is the source control measure identified for waste sites being remediated in the 300 Area. Remediation is nearly complete at the 300-FF-1 OU; however, further vadose zone investigations are needed to determine if residual contaminant inventories are continuing to contribute to groundwater. The 300-FF-2 OU waste sites within the 300 Area complex may also be contributing contamination to the groundwater; however, a major source from these waste sites is not anticipated. The 316-4 Crib and 618-11 Burial Ground are probable sources of contamination to groundwater, but the efficacy of MNA for groundwater plumes from these sources cannot be ascertained until source control is achieved. Any major remedial action excavations in the 300 Area will be documented in the annual PNNL groundwater monitoring report or a stand alone 300-FF-5 annual report. An effort will be made to correlate these excavations with changes in local groundwater quality and the groundwater contaminant plumes.

5.7.2 Near-River Residual Contamination Influence on Groundwater Quality

The impact that residual contamination in the vadose zone has on groundwater are being investigated. An ongoing K_d/leachability study is being conducted to better define the K_d value of uranium in the 300 Area vadose zone and groundwater. As part of this study, a sensitivity analysis of uranium K_d are being conducted using fate and transport modeling. Vadose zone sampling and/or laboratory evaluations to establish uranium K_d values and the geochemical processes influencing the uranium K_d values at the groundwater/vadose zone interface are also being conducted.

To evaluate bank recharge/discharge influence on contaminant mobilization from the deep vadose zone, seasonal groundwater sampling will be conducted. To determine the impact that residual uranium contamination in the vadose zone has on the groundwater, the concentrations in groundwater must be tracked to assess vadose storage and transport of contamination. A zone near the groundwater and several hundred meters wide (i.e., east of Stevens Drive [Route 4]) is influenced by high Columbia River stage changes. Within this zone, uranium contamination increases after high water due to remobilization. To address this seasonal variation, groundwater will be sampled to qualitatively assess the effect of Columbia River stage changes on groundwater contaminant remobilization. When river stage is lowest, groundwater/seeps will be sampled to determine the maximum COC concentrations (minimum bank recharge dilution influence) that exposed individuals (i.e., human, plant, and wildlife) could experience. When the river stage is highest, the groundwater would be sampled to determine the minimum COC concentrations (maximum bank recharge dilution influence near the river) that exposed individuals could experience.

To evaluate the effectiveness of MNA for the near-river area of concern, plume geometry will be mapped to determine whether high-concentration areas are shrinking over time. Trend plots of contaminant concentrations will be evaluated to determine if they are decreasing. The data will be inspected to see if degradation products are being generated. The conceptual contaminant fate and transport model will be evaluated and updated if necessary. Numerical groundwater modeling will supplement plume mapping and trend plot data to show containment concentration reductions and/or plume shrinking over time, and establish future point-of-compliance locations and dates.

5.7.3 Inland Waste Site Contamination Influence on Groundwater Quality

Groundwater contamination located west of Stevens Drive (Route 4) is not influenced by Columbia River stage changes. The wells used to monitor contaminant plumes associated with the 618-11 and 618-10/316-4 areas of concern require only annual sampling after the second year. Quarterly sampling is advised during the first two years when baseline conditions are being established. Plume geometry will be mapped to determine whether high-concentration areas are shrinking over time (despite potential active sources at these sites). Trend plots of contaminant concentrations will be evaluated to determine if they are decreasing. The data will be inspected to see if degradation products of VOAs are possibly being generated. The conceptual contaminant fate and transport model will be evaluated and updated if necessary. Numerical groundwater modeling will be considered if plume mapping and trend plot data do not adequately show the extent of contaminant concentration changes with respect to area and time.

5.8 ANALYTICAL AND DATA QUALITY ASSESSMENT REQUIREMENTS

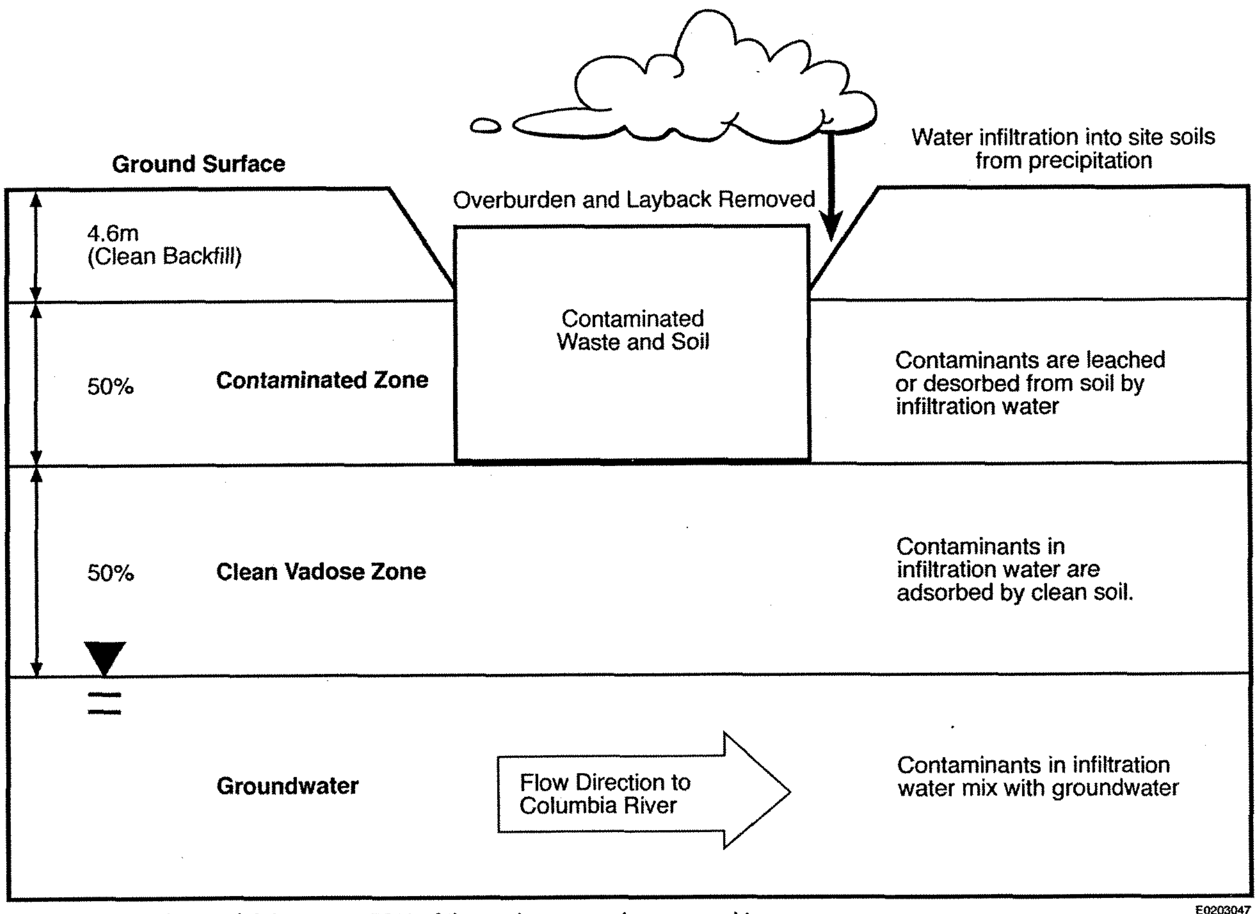
All samples will be collected and handled according to DOE contractor procedures. Sampling equipment will be decontaminated before use if not disposable or dedicated to the sampling location. Standard laboratory methods shall be used to determine contaminant concentrations in groundwater. Analytical methods, detection limits, and precision and accuracy requirements are provided in Table 5-6. A sampling authorization form, detailing laboratory-specific needs, shall be issued by the sample management organization prior to sampling activities.

All data packages received from the laboratory shall be checked for completeness and technical accuracy. The check shall consist of reviewing requested versus reported analyses and the evaluation of splits, blanks, and duplicate analyses. A data quality assessment will be documented in the annual groundwater report. Significant deviation from previous performance will be evaluated to determine if corrective sampling and analysis actions are required.

5.9 EVALUATE ADDITIONAL REMEDIAL ALTERNATIVES

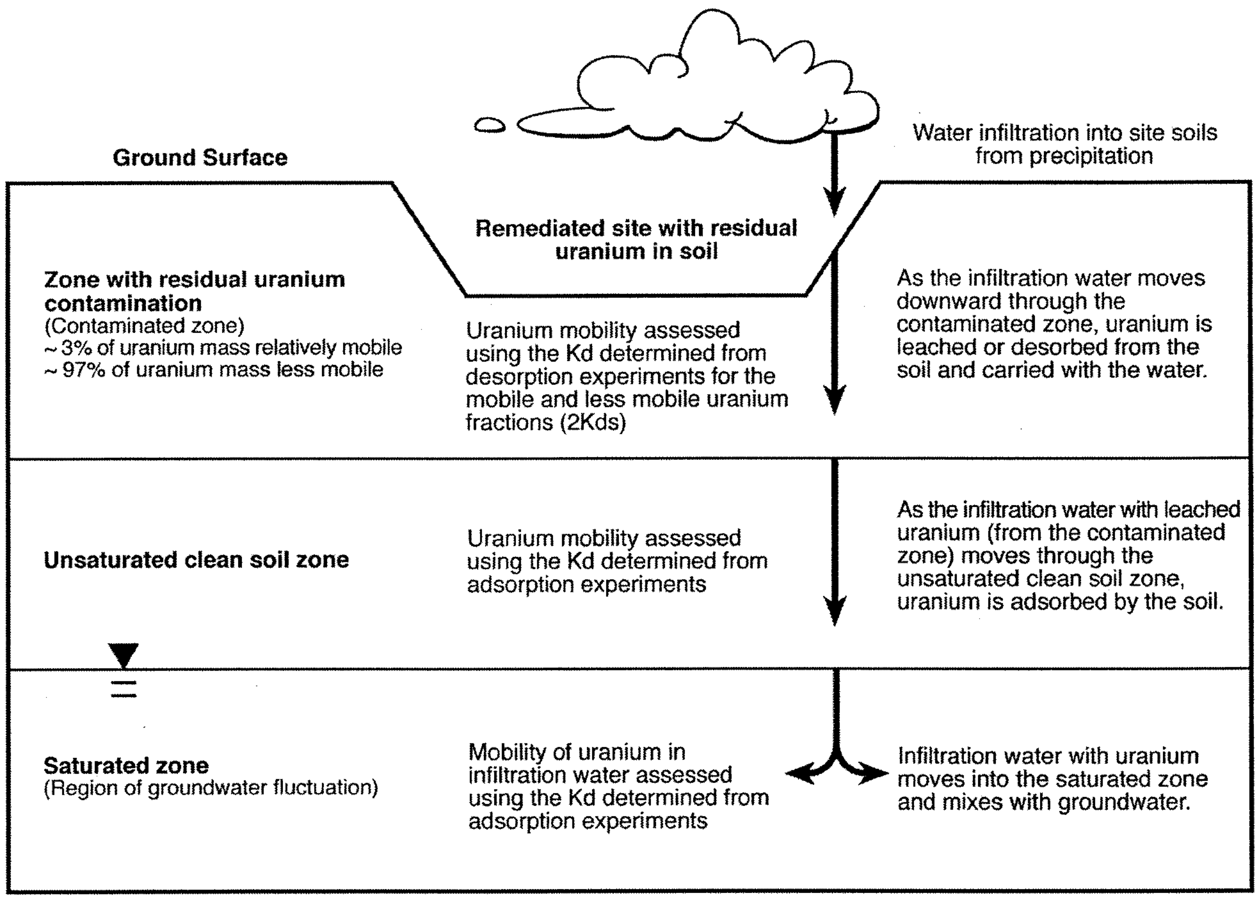
If MNA is shown to be ineffective, additional groundwater remediation alternatives will need to be considered, such as those evaluated in the 300-FF-5 RI/FS (DOE-RL 1995). If no alternatives prove to be practicable for achieving RAOs (e.g., based on long restoration time frames for achieving remedial action goals), ACLs or technical impracticability waivers under CERCLA would be considered by the Tri-Parties. Examples of innovative technologies being investigated for uranium treatment are provided in Table 5-7. Monitoring in the 300-FF-5 OU will continue as long as groundwater contaminants exceed remediation goals. Compliance with drinking water MCLs and/or AWQC shall be determined in accordance with WAC 173-340-720(8e).

Figure 5-1. Generic Waste Site Conceptual Model.



In the generic site-model the upper 50% of the vadose zone is assumed to be contaminated and the lower 50% is assumed to be clean. Contaminant transport through the contaminated zone, clean vadose zone, and groundwater (saturated zone) is assumed to be described by a single Kd value.

Figure 5-2. Preliminary Uranium Soil-to-Groundwater Conceptual Site Model.



1. This uranium soil-to-groundwater conceptual site model is preliminary, pending the results of an ongoing uranium K_d/leachability study. The purpose of this model is to provide a relatively simple and conservative model for use in assessing potential groundwater impacts from residual uranium in the soil following waste site remediation.

2. Depending on site characteristics, the unsaturated clean soil zone depicted in this figure may not be present for all waste sites.

Table 5-1. All Existing Monitoring Wells in 300-FF-5 Operable Unit. (10 Pages)

Well Name	Date of Completion	Total Depth (ft) and Well Screen or Perforated Interval (ft)	Program Using Well During FY02	Well Location Relative to COC Plume	Monitoring Well Inclusion/Exclusion Rationale	Additional Comments
399-1-1	November 1948	43 (20-43)	Not currently sampled	Inside of uranium plume; upgradient of TCE plume; inside of PCE, nitrate, and sitewide tritium plumes	Include; this well monitors the uranium and VOA plumes in the 300 Area.	
399-1-2	April 1950	55 (25-55)	Sitewide surveillance	Edge of uranium plume; upgradient of TCE plume; inside of PCE, nitrate, and sitewide tritium plumes	Include; this well monitors the uranium and VOA plumes in the 300 Area.	
399-1-3	April 1950	75 (25-70)	Sitewide surveillance	Inside of uranium plume; upgradient of TCE plume; inside of PCE, nitrate, and sitewide tritium plumes	Exclude; adequate coverage with other wells.	
399-1-4	May 1950	80 (23-70)	Not currently sampled	Upgradient of U plume; upgradient of TCE plume; inside of PCE, nitrate, and sitewide tritium plumes	Exclude; adequate coverage with other wells.	
399-1-5	February 1975	45 (23-45)	Not currently sampled	Not applicable	Exclude; well was decommissioned.	
399-1-6	February 1975	44 (22-44)	Long term monitoring, CERCLA	Upgradient of uranium plume, upgradient of TCE plume, upgradient of PCE plume, inside the nitrate and sitewide tritium plumes	Include; this well monitors the uranium and VOA plumes in the 300 Area.	
399-1-7	March 1985	54 (25-54)	Long term monitoring, CERCLA; RCRA	Inside of uranium plume; upgradient of TCE plume; inside of PCE, nitrate, and sitewide tritium plumes	Include; part of the 300 APT well network.	
399-1-8	August 1985	105 (85-105)	RCRA	Inside of uranium plume; upgradient of TCE plume; inside of PCE, nitrate, and sitewide tritium plumes	Include; part of the 300 APT well network.	
399-1-9	February 1987	178 (170-178)	Not currently sampled	Inside of uranium plume; upgradient of TCE plume; inside of PCE, nitrate, and sitewide tritium plumes	Exclude; adequate coverage with other wells.	
399-1-10A	November 1986	39 (24-39)	Sitewide surveillance; RCRA	Inside of uranium plume; upgradient of TCE plume; inside of PCE, nitrate, and sitewide tritium plumes	Include; part of the 300 APT well network.	Key indicator well[a]
399-1-10B	October 1991	115 (104-114)	Sitewide surveillance; RCRA	Inside of uranium plume; upgradient of TCE plume; inside of PCE, nitrate, and sitewide tritium plumes	Include; part of the 300 APT well network.	Well is WAC 173-160 compliant. Key indicator well[a]

Table 5-1. All Existing Monitoring Wells in 300-FF-5 Operable Unit. (10 Pages)

Well Name	Date of Completion	Total Depth (ft) and Well Screen or Perforated Interval (ft)	Program Using Well During FY02	Well Location Relative to COC Plume	Monitoring Well Inclusion/Exclusion Rationale	Additional Comments
300-1-11	November 1986	47 (25-47)	RCRA	Inside edge of uranium plume, upgradient of TCE plume, inside of PCE, nitrate, and sitewide tritium plumes	Include; part of the 300 APT well network.	Key indicator well[a]
399-1-12	November 1986	60 (45-60)	Long-term monitoring, CERCLA	Inside edge of uranium plume; upgradient of TCE plume; inside of PCE, nitrate, and sitewide tritium plumes	Include; well monitors the 300 Area uranium and VOA plumes.	Well is a substitute for 399-1-5, which was decommissioned. Key indicator well[a]
399-1-13A	October 1986	53 (38-53)	Sitewide surveillance	Upgradient of uranium plume; upgradient of TCE plume; inside of PCE, nitrate, and sitewide tritium plumes	Exclude; adequate coverage with other wells.	
399-1-13B	February 1992	119 (106-117)	Not currently sampled	Upgradient of uranium plume; upgradient of TCE plume; inside of PCE, nitrate, and sitewide tritium plumes	Exclude; adequate coverage with other wells.	Well is WAC 173-160 compliant.
399-1-14A	October 1986	47 (32-47)	Sitewide surveillance	Upgradient of uranium plume; upgradient of TCE plume; inside of PCE, nitrate, and sitewide tritium plumes	Exclude; adequate coverage with other wells.	
399-1-14B	October 1991	111 (99-109)	Not currently sampled	Upgradient of uranium plume; upgradient of TCE plume; inside of PCE, nitrate, and sitewide tritium plumes	Exclude; adequate coverage with other wells.	Well is WAC 173-160 compliant.
399-1-15	November 7, 1986	44 (29-44)	Not currently sampled	Upgradient of uranium plume, upgradient of TCE plume, upgradient of PCE plume, inside nitrate and sitewide tritium plumes	Include; well monitors the 618-4 area of concern.	Key indicator well[a]
399-1-16A	December 1986	47.5 (32-48)	Sitewide surveillance; RCRA	Inside of uranium plume; upgradient of TCE plume; inside of PCE, nitrate, and sitewide tritium plumes	Include; part of the 300 APT well network.	Well is WAC 173-160 compliant. Key indicator well[a]
399-1-16B	February 1987	115 (105-115)	Sitewide surveillance; RCRA	Inside of uranium plume; upgradient of TCE plume; inside of PCE, nitrate, and sitewide tritium plumes	Include; part of the 300 APT well network.	Key indicator well[a]
399-1-16C	January 1987	178 (167 -177)	Sitewide surveillance	Inside of uranium plume; upgradient of TCE plume; inside of PCE, nitrate, and sitewide tritium plumes	Exclude; adequate coverage with other wells.	

Table 5-1. All Existing Monitoring Wells in 300-FF-5 Operable Unit. (10 Pages)

Well Name	Date of Completion	Total Depth (ft) and Well Screen or Perforated Interval (ft)	Program Using Well During FY02	Well Location Relative to COC Plume	Monitoring Well Inclusion/Exclusion Rationale	Additional Comments
399-1-17A	November 1986	41 (25-40)	Sitewide surveillance; RCRA; DOH	Inside edge of uranium plume; upgradient of TCE plume; inside of PCE, nitrate, and sitewide tritium plumes	Include; part of the 300 APT well network.	Well is WAC 173-160 compliant. Key indicator well[a]
399-1-17B	December 1986	113 (100-110)	Sitewide surveillance; RCRA	Inside edge of uranium plume; upgradient of TCE plume; inside of PCE, nitrate, and sitewide tritium plumes	Include; part of the 300 APT well network.	Key indicator well[a]
399-1-17C	January 1987	171 (160-171)	Not currently sampled	Inside edge of uranium plume; upgradient of TCE plume; inside of PCE, nitrate, and sitewide tritium plumes	Exclude; adequate coverage with other wells.	
399-1-18A	November 1986	54 (39-54)	Sitewide surveillance; RCRA	Upgradient of uranium plume, upgradient of TCE plume, upgradient of PCE plume, inside the nitrate and sitewide tritium plumes	Include; well monitors the 300 Area uranium, nitrate, and VOA plumes.	Well is WAC 173-160 compliant.
399-1-18B	January 1987	118 (108-118)	Sitewide surveillance; RCRA	Upgradient of uranium plume, upgradient of TCE plume, upgradient of PCE plume, inside the nitrate and sitewide tritium plumes	Include; well monitors the 300 Area uranium, tritium, and VOA plumes.	Well is WAC 173-160 compliant.
399-1-18C	January 1987	140 (130-140)	Sitewide surveillance	Upgradient of uranium plume, upgradient of TCE plume, upgradient of the PCE plume, inside the nitrate and sitewide tritium plumes	Exclude; adequate coverage with other wells.	
399-1-19	May 1986	45 (35-45)	Not currently sampled	Inside edge of U plume, upgradient of TCE plume, inside of PCE plume, inside the nitrate plume and sitewide tritium plumes	Exclude; adequate coverage with other wells.	
399-1-20	December 1988	123 (43-120 [six intervals])	Not currently sampled	Inside of uranium plume, upgradient TCE plume, inside of PCE, nitrate, and sitewide tritium plumes	Exclude; adequate coverage with other wells.	
399-1-21A	September 1991	55 (31-52)	Sitewide surveillance	Inside of uranium plume, inside edge of TCE plume, upgradient of the PCE plume, inside the nitrate and sitewide tritium plumes	Include; part of the 300 APT well network.	Well is WAC 173-160 compliant.
399-1-21B	September 1991	112 (102-112)	Not currently sampled	Inside of uranium plume, inside edge of TCE plume, upgradient of the PCE plume, inside the nitrate and sitewide tritium plumes	Include; part of the 300 APT well network.	Well is WAC 173-160 compliant.

Table 5-1. All Existing Monitoring Wells in 300-FF-5 Operable Unit. (10 Pages)

Well Name	Date of Completion	Total Depth (ft) and Well Screen or Perforated Interval (ft)	Program Using Well During FY02	Well Location Relative to COC Plume	Monitoring Well Inclusion/Exclusion Rationale	Additional Comments
399-2-1	November 1948	45 (18-45)	Sitewide surveillance; long-term monitoring, CERCLA	Inside of uranium plume, inside of TCE plume, inside of PCE, nitrate, and sitewide tritium plumes	Include; well monitors the 300 Area uranium and VOA plumes.	
399-2-2	October 1976	57 (35-55)	Long term monitoring, CERCLA	Inside of uranium plume, inside edge of TCE plume, inside of PCE, nitrate, and sitewide tritium plumes	Include; well monitors the 300 Area uranium and VOA plumes.	
399-2-3	October 1976	61 (35-55)	Not currently sampled	Inside of uranium plume, inside edge of TCE plume, inside of PCE, nitrate, and sitewide tritium plumes	Exclude; adequate coverage with other wells.	
399-3-1	October 1948	74 (20-65 [three intervals])	Sitewide surveillance	Inside of uranium plume; inside edge of TCE plume; inside of PCE, nitrate, and sitewide tritium plumes	Exclude; adequate coverage with other wells.	
399-3-2	October 1947	102 (40-75)	Sitewide surveillance	Upgradient of uranium plume, inside edge of TCE plume, upgradient of the PCE plume, inside of nitrate plume, outside of sitewide tritium plume	Include; well monitors the 300-11 (near the 382 Building) area of concern.	Key sentry well[b]
399-3-3	January 1948	81 (52-81)	Sitewide surveillance	Upgradient of uranium plume, inside edge of TCE plume, upgradient of the PCE plume, inside of nitrate plume, outside of sitewide tritium plume	Exclude; adequate coverage with other wells.	
399-3-6	August 1943	85 (42-55)	Sitewide surveillance	Inside edge of uranium plume, inside edge of TCE plume, upgradient of PCE plume, inside the nitrate plume, outside the sitewide tritium plume	Include; well monitors the 384 Powerhouse and 300-11 areas of concern.	Replaces decommissioned wells 399-3-4B and 399-3-7. Key sentry well[b]
399-3-7	January 1944	86 (N/A)	Not currently sampled	Not applicable	Exclude; this well was decommissioned in 1993.	
399-3-8	March 1970	48 (28-48)	Not currently sampled	Inside of uranium plume, inside of TCE plume, upgradient of PCE plume, inside the nitrate and sitewide tritium plumes	Exclude; adequate coverage with other wells.	
399-3-9	August 1976	65 (45-55)	Not currently sampled	Inside of uranium, TCE, PCE, nitrate, and sitewide tritium plumes	Exclude; adequate coverage with other wells.	

Table 5-1. All Existing Monitoring Wells in 300-FF-5 Operable Unit. (10 Pages)

Well Name	Date of Completion	Total Depth (ft) and Well Screen or Perforated Interval (ft)	Program Using Well During FY02	Well Location Relative to COC Plume	Monitoring Well Inclusion/Exclusion Rationale	Additional Comments
399-3-10	September 1976	62 (34-49)	Sitewide surveillance	Inside of uranium, TCE, PCE, nitrate, and sitewide tritium plumes	Include; well monitors the 300 Area uranium, nitrate, and VOA plumes.	
399-3-11	September 1976	70 (45-65)	Sitewide surveillance	Inside of uranium and TCE plumes, upgradient of PCE plume, inside the nitrate and sitewide tritium plumes	Include; well monitors the 324 Building area of concern.	Key indicator well[a]
399-3-12	September 1980	48 (35-49)	Sitewide surveillance; long-term monitoring, CERCLA	Inside of uranium and TCE plumes, upgradient of PCE plume, inside the nitrate and sitewide tritium plumes	Include; well monitors the 300 Area uranium, nitrate, tritium, and VOA plumes.	
399-4-1	February 1951	64 (25-64)	Sitewide surveillance; long-term monitoring, CERCLA	Inside edge of uranium and TCE plumes, upgradient of PCE plume, inside the nitrate plume, outside the sitewide tritium plume	Include; well monitors the 300 Area uranium, nitrate, tritium, and VOA plumes.	
399-4-5	August 1958	196 (N/A)	Not currently sampled	Not applicable	Exclude; this well was decommissioned in 1993.	
399-4-7	November 1961	46 (21-46)	Sitewide surveillance	Inside of uranium, TCE, PCE, nitrate, and sitewide tritium plumes	Exclude; adequate coverage with other wells.	
399-4-8	October 1971	72 (N/A)	Not currently sampled	Not applicable	Exclude; this well was decommissioned in 1993.	
399-4-9	September 1976	59 (38-58)	Sitewide surveillance; long-term monitoring, CERCLA	Inside of uranium, TCE, PCE, nitrate, and sitewide tritium plumes	Include; well monitors the 300 Area uranium, nitrate, tritium, and VOA plumes.	
399-4-10	September 1976	55 (37-50)	Sitewide surveillance	Inside of uranium, TCE, PCE, nitrate, and sitewide tritium plumes	Exclude; adequate coverage with other wells.	

Table 5-1. All Existing Monitoring Wells in 300-FF-5 Operable Unit. (10 Pages)

Well Name	Date of Completion	Total Depth (ft) and Well Screen or Perforated Interval (ft)	Program Using Well During FY02	Well Location Relative to COC Plume	Monitoring Well Inclusion/Exclusion Rationale	Additional Comments
399-4-11	November 26, 1986	70 (55-70)	Sitewide surveillance	Upgradient of uranium plume, inside edge of TCE plume, upgradient of PCE plume, inside the nitrate plume, outside the sitewide tritium plume	Exclude; adequate coverage with other wells.	
399-4-12	December 1980	69 (49-69)	Sitewide surveillance; long-term monitoring, CERCLA	Inside edge of uranium and TCE plumes, upgradient of PCE plume, inside the nitrate and sitewide tritium plumes	Include; well monitors the 300 Area uranium, nitrate, tritium, and VOA plumes.	
399-5-1	February 1951	90 (23-100)	Sitewide surveillance	Outside of uranium plume, inside of TCE plume, upgradient of PCE plume, inside the nitrate plume, outside the sitewide tritium plume	Exclude; adequate coverage with other wells.	
399-5-2	July 1954	417 (192-412)	Not currently sampled	Upgradient of uranium, TCE, and PCE plumes, inside the nitrate plume, outside the sitewide tritium plume	Exclude; adequate coverage with other wells.	
399-5-4B	April 1993	57 (42-57)	Sitewide surveillance	Upgradient of uranium, TCE, and PCE plumes, inside the nitrate plume, outside the sitewide tritium plume	Include; well monitors the 300-5 (near 3709A Fire Station) area of concern.	Well is WAC 173-160 compliant.
399-6-1	May 1950	62 (24-75)	Sitewide surveillance	Upgradient of uranium, TCE, and PCE plumes, inside the nitrate plume, outside the sitewide tritium plume	Exclude; adequate coverage with other wells.	
399-6-2	May 1993	65 (43-58)	Sitewide surveillance	Upgradient of uranium, TCE, and PCE plumes, inside the nitrate plume, outside the sitewide tritium plume	Exclude; adequate coverage with other wells.	Well is WAC 173-160 compliant.
399-8-1	April 1950	98 (35-83)	Sitewide surveillance	Upgradient of uranium, TCE, and PCE plumes, inside the nitrate plume, outside the sitewide tritium plume	Exclude; adequate coverage with other wells.	
399-8-2	May 1950	92 (43-72)	Not currently sampled	Upgradient of uranium, TCE, and PCE plumes, inside the nitrate plume, outside the sitewide tritium plume	Exclude; adequate coverage with other wells.	

Table 5-1. All Existing Monitoring Wells in 300-FF-5 Operable Unit. (10 Pages)

Well Name	Date of Completion	Total Depth (ft) and Well Screen or Perforated Interval (ft)	Program Using Well During FY02	Well Location Relative to COC Plume	Monitoring Well Inclusion/Exclusion Rationale	Additional Comments
399-8-3	March 1951	94 (25-99)	Not currently sampled	Upgradient of uranium, TCE, and PCE plumes, inside the nitrate plume, inside the sitewide tritium plume	Exclude; adequate coverage with other wells.	
399-8-4	September 1979	61 (42-60)	Not currently sampled	Upgradient of uranium, TCE, and PCE plumes, inside the nitrate plume, outside the sitewide tritium plume	Exclude; adequate coverage with other wells.	
399-8-5A	November 12, 1991	72 (50-70)	Sitewide surveillance	Upgradient of uranium, TCE, and PCE plumes, inside the nitrate plume, outside the sitewide tritium plume	Include; well monitors the 618-7 Burial Ground area of concern.	Well is WAC 173-160 compliant. Key indicator well[a]
399-8-5B	December 1991	168 (154-165)	Sitewide surveillance	Upgradient of uranium, TCE, and PCE plumes, inside the nitrate plume, outside the sitewide tritium plume	Exclude; adequate coverage with other wells.	Well is WAC 173-160 compliant.
399-8-5C	December 1991	208 (190-205)	Sitewide surveillance	Upgradient of uranium, TCE, and PCE plumes, inside the nitrate plume, outside the sitewide tritium plume	Exclude; adequate coverage with other wells.	Well is WAC 173-160 compliant.
699-12-1A	November 1972	846 (N/A)	Not currently sampled	Inside the nitrate and 618-11 tritium plumes	Possibly include; this well may be included in the 618-11 monitoring plan.	
699-13-2B	November 1972	875 (N/A)	Not currently sampled	Inside the nitrate and 618-11 tritium plumes	Possibly include; this well may be included in the 618-11 monitoring plan.	
699-13-3A	September 1995	78 (56-76)	Sitewide surveillance; CERCLA	Inside the nitrate and 618-11 tritium plumes	Include; this well is part of monitoring for the 618-11 Burial Ground.	Well is WAC 173-160 compliant. Key indicator well[a]
699-12-2C	September 2001	85.4 (60.6-80.67)	Not currently sampled	Inside 618-11 tritium plume	Include; this well is part of monitoring for the 618-11 Burial Ground.	Well is WAC 173-160 compliant. Key indicator well[a]
699-13-2D	September 2001	108 (57.97-78.03)	Not currently sampled	Inside 618-11 tritium plume	Include; this well is part of monitoring for the 618-11 Burial Ground.	Well is WAC 173-160 compliant. Key indicator well[a]

Table 5-1. All Existing Monitoring Wells in 300-FF-5 Operable Unit. (10 Pages)

Well Name	Date of Completion	Total Depth (ft) and Well Screen or Perforated Interval (ft)	Program Using Well During FY02	Well Location Relative to COC Plume	Monitoring Well Inclusion/Exclusion Rationale	Additional Comments
699-13-0A	September 2001	56.17 (31.19-51.24)	Not currently sampled	Inside 618-11 tritium plume.	Include; this well is part of monitoring for the 618-11 Burial Ground.	Well is WAC 173-160 compliant. Key sentry well[b]
699-13-1E	September 2001	83.4 (57.67-77.57)	Not currently sampled	Inside 618-11 tritium plume	Include; this well is part of monitoring for the 618-11 Burial Ground.	Well is WAC 173-160 compliant. Key indicator well[a]
699-14-E3E	May 1974	629 (N/A)	Not currently sampled	Inside the nitrate and sitewide tritium plumes	Exclude; developed in the basalt-confined aquifer.	
699-S6-E4A	April 1948	106 (71-91)	Sitewide surveillance; CERCLA	Inside uranium, nitrate, and sitewide tritium plumes	Include; well monitors the 618-10 and 316-4 area of concern.	This is the only down-gradient well from 618-10 and 316-4 that currently shows any COCs. Well is WAC 173-160 compliant. Key indicator well[a]
699-S6-E4B	March 1953	87 (48-77)	Sitewide surveillance	Downgradient of 316-4 uranium plume, inside the nitrate and sitewide tritium plumes	Include; well monitors the 618-10 and 316-4 area of concern.	
699-S6-E4C	May 1953	443 (145-150, 227-232)	Sitewide surveillance	Edge of 316-4 uranium plume, inside the nitrate and sitewide tritium plumes	Exclude; adequate coverage with other wells.	
699-S6-E4D	November 1953	72 (33-83)	Sitewide surveillance	Cross-gradient of 316-4 uranium plume, inside the nitrate and sitewide tritium plumes	Include; well monitors the 618-10 and 316-4 area of concern.	
699-S6-E4E	November 1953	77 (58-100)	Not currently sampled	Cross-gradient of 316-4 uranium plume, inside the nitrate plume, inside the sitewide tritium plume	Include, if no new wells are drilled around 618-10 and 316-4.	This well was chosen from the following wells to add: 699-S6-E4E, 699-S6-E4F, or 699-S6-E4G.
699-S6-E4F	January 1954	92 (52-100)	Not currently sampled	Cross/downgradient of 316-4 uranium plume, inside the nitrate plume, inside the sitewide tritium plume	Exclude; adequate coverage with other wells.	

Table 5-1. All Existing Monitoring Wells in 300-FF-5 Operable Unit. (10 Pages)

Well Name	Date of Completion	Total Depth (ft) and Well Screen or Perforated Interval (ft)	Program Using Well During FY02	Well Location Relative to COC Plume	Monitoring Well Inclusion/Exclusion Rationale	Additional Comments
699-S6-E4G	January 1954	102 (50-100)	Not currently sampled	Cross/downgradient of 316-4 uranium plume, inside the nitrate and sitewide tritium plumes	Exclude; adequate coverage with other wells.	
699-S19-E13	November 1971	78 (50-78)	Sitewide surveillance	Upgradient of uranium, TCE, and PCE plumes, inside the nitrate and sitewide tritium plume	Exclude; adequate coverage with other wells.	
699-S19-E14	September 1991	47 (19-40)	Sitewide surveillance	Upgradient of uranium, TCE, and PCE plumes, inside the nitrate and sitewide tritium plumes	Exclude; adequate coverage with other wells.	Well is WAC 173-160 compliant.
699-S22-E9A	September 1991	45 (23-38)	Sitewide surveillance	Upgradient of uranium, TCE, and PCE plumes, inside the nitrate plume, outside the sitewide tritium plume	Exclude; adequate coverage with other wells.	Well is WAC 173-160 compliant.
699-S22-E9B	September 1991	151 (137-148)	Not currently sampled	Upgradient of uranium, TCE, and PCE plumes, inside the nitrate plume, outside the sitewide tritium plume	Exclude; adequate coverage with other wells.	Well is WAC 173-160 compliant.
699-S22-E9C	September 1991	181.6 (174-179)	Sitewide surveillance	Upgradient of uranium, TCE, and PCE plumes, inside the nitrate plume, outside the sitewide tritium plume	Exclude; adequate coverage with other wells.	Well is WAC 173-160 compliant.
699-S27-E9A	June 1991	59 (35-55)	Sitewide surveillance	Upgradient of uranium, TCE, and PCE plumes, inside the nitrate plume, outside the sitewide tritium plume	Exclude; adequate coverage with other wells.	
699-S27-E9B	September 1991	179 (165-176)	Sitewide surveillance	Upgradient of uranium, TCE, and PCE plumes, inside the nitrate plume, outside the sitewide tritium plume	Exclude; adequate coverage with other wells.	Well is WAC 173-160 compliant.
699-S27-E9C	September 1991	202 (195-200)	Sitewide surveillance	Upgradient of uranium, TCE, and PCE plumes, inside the nitrate plume, outside the sitewide tritium plume	Exclude; adequate coverage with other wells.	Well is WAC 173-160 compliant.
699-S27-E14	April 1948	105 (60-150)	Sitewide surveillance	Upgradient of uranium plume, outside edge of TCE plume, upgradient of PCE plume, inside the nitrate plume, outside the sitewide tritium plume	Exclude; adequate coverage with other wells.	

Table 5-1. All Existing Monitoring Wells in 300-FF-5 Operable Unit. (10 Pages)

Well Name	Date of Completion	Total Depth (ft) and Well Screen or Perforated Interval (ft)	Program Using Well During FY02	Well Location Relative to COC Plume	Monitoring Well Inclusion/Exclusion Rationale	Additional Comments
699-S28-E12	May 1991	58 (35-56)	Sitewide surveillance; long-term monitoring, CERCLA	Upgradient of uranium plume, inside of TCE plume, upgradient PCE plume, inside the nitrate plume, outside the sitewide tritium plume	Exclude; adequate coverage with other wells.	
699-S29-E12	November 1971	79 (37-79)	Sitewide surveillance	Upgradient of uranium plume, edge of TCE plume, upgradient of PCE plume, inside the nitrate plume, outside the sitewide tritium plume	Exclude; adequate coverage with other wells.	
699-S29-E16A	September 1991	52 (28-48)	Sitewide surveillance	Outside of uranium, TCE , and PCE plumes, inside the nitrate plume, outside the sitewide tritium plume	Exclude; adequate coverage with other wells.	Well is WAC 173-160 compliant.
699-S29-E16B	September 1991	119 (94-104)	Sitewide surveillance	Outside of uranium, TCE , and PCE plumes, inside the nitrate plume, outside the sitewide tritium plume	Exclude; adequate coverage with other wells.	Well is WAC 173-160 compliant.
699-S29-E16C	September 1991	178 (166-176)	Sitewide surveillance	Outside of uranium, TCE , and PCE plumes, inside the nitrate plume, outside the sitewide tritium plume	Exclude; adequate coverage with other wells.	Well is WAC 173-160 compliant.
699-S30-E14	August 1962	211 (45-160)	Not currently sampled	Outside of uranium, TCE , and PCE plumes, inside the nitrate plume, outside the sitewide tritium plume	Exclude; adequate coverage with other wells.	
699-S30-E15A	October 1971	78 (58-78)	Sitewide surveillance; DOH	Outside of uranium, TCE , and PCE plumes, inside the nitrate plume, outside the sitewide tritium plume	Exclude; adequate coverage with other wells.	
699-S30-E15B	October 1971	93 (N/A)	Not currently sampled	Outside of uranium, TCE , and PCE plumes, inside the nitrate plume, outside the sitewide tritium plume	Exclude; adequate coverage with other wells.	

NOTE: Wells shown in gray shade are not used to support 300-FF-5 objectives and are not included in Table 5-2.
[a]These monitoring wells are generally located close to the suspected sources of the 300-FF-5 contaminant plumes and provide key information regarding near-field plume conditions.
[b]These monitoring wells are generally located near the downgradient boundaries of the 300-FF-5 contaminant plumes and provide key information regarding far-field plume conditions.
APT = area process trench
DCE = dichloroethylene
PCE = tetrachloroethylene
N/A = Not available
TCE = trichloroethylene

Table 5-2. Monitoring Wells Required by the 300-FF-5 O&M Plan, Organized by Contaminant Plume. (5 Pages)

Well	Contaminant Plumes/Areas of Concern	Sampling Frequency[a] and Type of Analyses[b]														Comments
		Alkalinity	pH	Anions	ICP Metals (6010A RCRA)	Semi-VOA	VOA (8010)	VOA (8260A RCRA)[c]	Alpha	Beta	Gamma	Iodine-129	Strontium-90	Tritium	Uranium (chemical [total])	
300 Area Uranium Plume																
399-1-1	Uranium and VOA plumes	SA	SA	SA				SA							SA	
399-1-2	Uranium and VOA plumes	SA	SA	SA				SA							SA	
399-1-6	Uranium and VOA plumes	SA	SA	SA				SA							SA	
399-1-7	300 Area Process Trenches[d]	SA	SA					SA							SA	
399-1-8	300 Area Process Trenches[d]	SA	SA					SA							SA	
399-1-10A	Site-wide nitrate and tritium plumes; 300 Area Process Trenches[d]	SA	SA	SA				SA							SA	Key indicator well for VOA and uranium plumes[f]
399-1-10B	Site-wide nitrate and tritium plumes; 300 Area Process Trenches[d]	SA	SA					SA						SA	SA	Key indicator well for VOA and uranium plumes[f]
399-1-11	300 Area Process Trenches[d]	SA	SA					SA							SA	Key indicator well for VOA and uranium plumes[f]
399-1-12	Uranium and VOA plumes	SA	SA					SA							SA	Key indicator well for VOA and uranium plumes[f]
399-1-16A	Site-wide nitrate and tritium plumes; 300 Area Process Trenches[d]	SA	SA	SA				SA							SA	Key indicator well for VOA and uranium plumes[f]
399-1-16B	Site-wide nitrate and tritium plumes; 300 Area Process Trenches[d]	SA	SA					SA							SA	Deep unconfined well, Key indicator well for VOA and uranium plumes[f]
399-1-17A	Site-wide nitrate and tritium plumes; 300 Area Process Trenches[d]	SA	SA	SA				SA	SA	SA				SA	SA	Key indicator well for VOA and uranium plumes[f]
399-1-17B	Site-wide nitrate and tritium plumes; 300 Area Process Trenches[d]	SA	SA					SA							SA	Deep unconfined well, Key indicator well for VOA and uranium plumes[f]
399-1-21A	Site-wide nitrate and tritium plumes; 300 Area Process Trenches[d]	SA	SA					SA						SA	SA	
399-1-21B	Site-wide nitrate and tritium plumes; 300 Area Process Trenches[d]	SA	SA					SA							SA	Deep unconfined well
399-2-1	Uranium and VOA plumes	SA	SA					SA							SA	
399-2-2	Uranium and VOA plumes	SA	SA					SA							SA	
399-3-10	Uranium and VOA plumes	SA	SA					SA							SA	
399-3-11	Uranium, VOA, site-wide nitrate and tritium, and 324 Building (Sr-90) plumes	SA	SA	SA				SA	SA	SA			SA	SA	SA	Key indicator well for Sr-90 and uranium plumes[f]
399-3-12	Uranium, VOA, and site-wide nitrate and tritium plumes	SA	SA	SA				SA						SA	SA	

Table 5-2. Monitoring Wells Required by the 300-FF-5 O&M Plan, Organized by Contaminant Plume. (5 Pages)

Well	Contaminant Plumes/Areas of Concern	Sampling Frequency[a] and Type of Analyses[b]														Comments
		Alkalinity	pH	Anions	ICP Metals (6010A RCRA)	Semi-VOA	VOA (8010)	VOA (8260A RCRA)[c]	Alpha	Beta	Gamma	Iodine-129	Strontium-90	Tritium	Uranium (chemical [total])	
399-4-1	Uranium, VOA, and site-wide nitrate and tritium plumes	SA	SA	SA				SA						SA	SA	
399-4-9	Uranium, VOA, and site-wide nitrate and tritium plumes	SA	SA	SA				SA						SA	SA	
399-4-12	Uranium, VOA, and site-wide nitrate and tritium plumes	SA	SA	SA				SA						SA[e]	SA	
300 Area VOA Plumes																
399-1-1	Uranium and VOA plumes	SA	SA	SA				SA							SA	
399-1-2	Uranium and VOA plumes	SA	SA	SA				SA							SA	
399-1-6	Uranium and VOA plumes	SA	SA	SA				SA							SA	
399-1-7	300 Area Process Trenches[d]	SA	SA					SA							SA	
399-1-8	300 Area Process Trenches[d]	SA	SA					SA							SA	
399-1-10A	Site-wide nitrate and tritium plumes; 300 Area Process Trenches[d]	SA	SA	SA				SA							SA	Key indicator well for VOA and uranium plumes[f]
399-1-10B	Site-wide nitrate and tritium plumes; 300 Area Process Trenches[d]	SA	SA					SA						SA	SA	Key indicator well for VOA and uranium plumes[f]
399-1-11	300 Area Process Trenches[d]	SA	SA					SA							SA	Key indicator well for VOA and uranium plumes[f]
399-1-12	Uranium and VOA plumes	SA	SA					SA							SA	Key indicator well for VOA and uranium plumes[f]
399-1-16A	Site-wide nitrate and tritium plumes; 300 Area Process Trenches[d]	SA	SA	SA				SA							SA	Key indicator well for VOA and uranium plumes[f]
399-1-16B	Site-wide nitrate and tritium plumes; 300 Area Process Trenches[d]	SA	SA					SA							SA	Deep unconfined well, Key indicator well for VOA and uranium plumes[f]
399-1-17A	Site-wide nitrate and tritium plumes; 300 Area Process Trenches[d]	SA	SA	SA				SA	SA	SA				SA	SA	Key indicator well for VOA and uranium plumes[f]
399-1-17B	Site-wide nitrate and tritium plumes; 300 Area Process Trenches[d]	SA	SA					SA							SA	Deep unconfined well, Key indicator well for VOA and uranium plumes[f]
399-1-21A	Site-wide nitrate and tritium plumes; 300 Area Process Trenches[d]	SA	SA					SA						SA	SA	
399-1-21B	Site-wide nitrate and tritium plumes; 300 Area Process Trenches[d]	SA	SA					SA							SA	Deep unconfined well
399-2-1	Uranium and VOA plumes	SA	SA					SA							SA	
399-2-2	Uranium and VOA plumes	SA	SA					SA							SA	

Table 5-2. Monitoring Wells Required by the 300-FF-5 O&M Plan, Organized by Contaminant Plume. (5 Pages)

Well	Contaminant Plumes/Areas of Concern	Sampling Frequency[a] and Type of Analyses[b]														Comments
		Alkalinity	pH	Anions	ICP Metals (6010A RCRA)	Semi-VOA	VOA (8010)	VOA (8260A RCRA)[c]	Alpha	Beta	Gamma	Iodine-129	Strontium-90	Tritium	Uranium (chemical [total])	
399-3-10	Uranium and VOA plumes	SA	SA					SA							SA	
399-3-11	Uranium, VOA, site-wide nitrate and tritium, and 324 Building (Sr-90) plumes	SA	SA	SA				SA	SA	SA			SA	SA	SA	Key indicator well for Sr-90 and uranium plumes[f]
399-3-12	Uranium, VOA, and site-wide nitrate and tritium plumes	SA	SA	SA				SA						SA	SA	
399-4-1	Uranium, VOA, and site-wide nitrate and tritium plumes	SA	SA	SA				SA						SA	SA	
399-4-9	Uranium, VOA, and site-wide nitrate and tritium plumes	SA	SA	SA				SA						SA	SA	
399-4-12	Uranium, VOA, and site-wide nitrate and tritium plumes	SA	SA	SA				SA						SA[e]	SA	
Nitrate Plume (Site-wide)																
399-1-10A	Site-wide nitrate and tritium plumes; 300 Area Process Trenches[d]	SA	SA	SA				SA							SA	Key indicator well for VOA and uranium plumes[f]
399-1-17A	Site-wide nitrate and tritium plumes; 300 Area Process Trenches[d]	SA	SA	SA				SA	SA	SA				SA	SA	Key indicator well for VOA and uranium plumes[f]
399-1-18A	Site-wide nitrate plume	SA	SA	SA												
399-3-11	Uranium, VOA, site-wide nitrate and tritium, and 324 Building (Sr-90) plumes	SA	SA	SA				SA	SA	SA			SA	SA	SA	Key indicator well for Sr-90 and uranium plumes[f]
399-3-12	Uranium, VOA, and site-wide nitrate and tritium plumes	SA	SA	SA				SA						SA	SA	
399-4-1	Uranium, VOA, and site-wide nitrate and tritium plumes	SA	SA	SA				SA						SA	SA	
399-4-9	Uranium, VOA, and site-wide nitrate and tritium plumes	SA	SA	SA				SA						SA	SA	
399-4-12	Uranium, VOA, and site-wide nitrate and tritium plumes	SA	SA	SA				SA						SA[e]	SA	
Tritium Plume (Site-wide)																
399-1-10B	Site-wide nitrate and tritium plumes; 300 Area Process Trenches[d]	SA	SA					SA						SA	SA	Key indicator well for VOA and uranium plumes[f]
399-1-17A	Site-wide nitrate and tritium plumes; 300 Area Process Trenches[d]	SA	SA	SA				SA	SA	SA				SA	SA	Key indicator well for VOA and uranium plumes[f]
399-1-18B	Site-wide tritium plume	SA	SA											SA		Deep unconfined well,
399-3-6	Site-wide tritium plus the 384 Powerhouse/300-11 areas (potential petroleum hydrocarbon) plumes	SA	SA	SA				SA						SA	SA	
399-3-11	Uranium, VOA, site-wide nitrate and tritium, and 324 Building (Sr-90) plumes	SA	SA	SA				SA	SA	SA			SA	SA	SA	Key indicator well for Sr-90 and uranium plumes[f]
399-3-12	Uranium, VOA, and site-wide nitrate and tritium plumes	SA	SA	SA				SA						SA	SA	
399-4-1	Uranium, VOA, and site-wide nitrate and tritium plumes	SA	SA	SA				SA						SA	SA	

Table 5-2. Monitoring Wells Required by the 300-FF-5 O&M Plan, Organized by Contaminant Plume. (5 Pages)

Well	Contaminant Plumes/Areas of Concern	Sampling Frequency[a] and Type of Analyses[b]														Comments
		Alkalinity	pH	Anions	ICP Metals (6010A RCRA)	Semi-VOA	VOA (8010)	VOA (8260A RCRA)[c]	Alpha	Beta	Gamma	Iodine-129	Strontium-90	Tritium	Uranium (chemical [total])	
399-4-9	Uranium, VOA, and site-wide nitrate and tritium plumes	SA	SA	SA				SA						SA	SA	
399-4-12	Uranium, VOA, and site-wide nitrate and tritium plumes	SA	SA	SA				SA						SA[e]	SA	
399-5-4B	Site-wide tritium and the 300-5 area (potential petroleum hydrocarbon) plumes	SA	SA					SA						SA[e]		
399-8-5A	Site-wide tritium plume and the 618-7 Burial Ground area (potential releases)	SA	SA	SA				SA	SA	SA				SA[e]	SA	
699-S6-E4B	Site-wide nitrate and tritium plumes; 618-10 Burial Ground area (potential releases)	SA	SA						A	A	A			A	A	Key indicator well for potential 618-10/316-4 releases[f]
699-S6-E4D	Site-wide nitrate and tritium plumes; 618-10 Burial Ground area (potential releases)	SA	SA						A	A	A			A	A	
618-4 Burial Ground (potential uranium plume)																
399-1-15	618-4 Burial Ground	SA	SA					SA	SA	SA					SA	Key indicator well for potential 618-4 releases[f]
618-7 Burial Ground (potential releases from the burial ground)																
399-8-5A	Site-wide tritium plume, 618-7 Burial Ground area (potential releases)	SA	SA	SA				SA	SA	SA				SA[e]	SA	Key indicator well for potential 618-7 releases[f]
384 Powerhouse (potential petroleum hydrocarbon plume)																
399-3-6	Site-wide tritium plus the 384 Powerhouse/300-11 areas (potential petroleum hydrocarbon) plumes	SA	SA	SA				SA						SA	SA	Key sentry well for potential 384 releases[g]
324 Building (Strontium-90 Plume)																
399-3-11	Uranium, VOA, site-wide nitrate and tritium, and 324 Building (Sr-90) plumes	SA	SA	SA				SA	SA	SA			SA	SA	SA	Key indicator well for Sr-90 and uranium plumes[f]
300-5 (Near 3709A Fire Station; potential petroleum hydrocarbon plume)																
399-5-4B	Site-wide tritium and the 300-5 area (potential petroleum hydrocarbon) plumes	SA	SA					SA						SA[e]		Key sentry well for potential 300-5 releases[g]
300-11 (Near the 382 Building; potential petroleum hydrocarbon plume)																
399-3-2	300-11 waste site area (potential petroleum hydrocarbon)	SA	SA					SA								Key sentry well for potential 300-11 releases[g]
399-3-6	Site-wide tritium plus the 384 Powerhouse/300-11 areas (potential petroleum hydrocarbon) plumes	SA	SA	SA				SA						SA	SA	Key sentry well for potential 300-11 releases[g]

Table 5-2. Monitoring Wells Required by the 300-FF-5 O&M Plan, Organized by Contaminant Plume. (5 Pages)

Well	Contaminant Plumes/Areas of Concern	Sampling Frequency[a] and Type of Analyses[b]														Comments
		Alkalinity	pH	Anions	ICP Metals (6010A RCRA)	Semi-VOA	VOA (8010)	VOA (8260A RCRA)[c]	Alpha	Beta	Gamma	Iodine-129	Strontium-90	Tritium	Uranium (chemical [total])	
618-10 Burial Ground (potential releases from the burial ground and site-wide tritium and nitrate plumes)																
699-S6-E4A	Site-wide nitrate and tritium plumes; 618-10 Burial Ground area (potential releases)	SA	SA	SA	SA	SA		SA	SA	SA	SA			SA	SA	Key indicator well for potential 618-10/316-4 releases[f]
699-S6-E4B	Site-wide nitrate and tritium plumes; 618-10 Burial Ground area (potential releases)	SA	SA						A	A	A			A	A	
699-S6-E4D	Site-wide nitrate and tritium plumes; 618-10 Burial Ground area (potential releases)	SA	SA						A	A	A			A	A	
699-S6-E4E	Site-wide nitrate and tritium plumes; 618-10 Burial Ground area (potential releases)	SA	SA						A	A	A			A	A	
Future well 1	Site-wide nitrate and tritium plumes; 618-10 Burial Ground area (potential releases)	SA	SA													Key indicator well for potential 618-10 releases[f]; Construction schedule TBD
Future well 2	Site-wide nitrate and tritium plumes; 618-10 Burial Ground area (potential releases)	SA	SA													Key indicator well for potential 618-10 releases[f]; Construction schedule TBD
618-11 Burial Ground (tritium plume)																
699-13-3A	618-11 Burial Ground area (tritium plume)	SA	SA	SA	A			A	Q	Q	Q	SA		Q	Q	Key indicator well for the 618-11 tritium plume[f]
699-12-2C	618-11 Burial Ground area (tritium plume)	SA	SA	SA	A			A	Q	Q	Q	SA		Q	Q	Key indicator well for the 618-11 tritium plume[f]
699-13-2D	618-11 Burial Ground area (tritium plume)	SA	SA	SA	A			A	Q	Q	Q	SA		Q	Q	Key indicator well for the 618-11 tritium plume[f]
699-13-0A	618-11 Burial Ground area (tritium plume)	SA	SA	SA	A			A	Q	Q	Q	SA		Q	Q	Sentry well for 618-11 tritium plume[g]
699-13-1E	618-11 Burial Ground area (tritium plume)	SA	SA	SA	A			A	Q	Q	Q	SA		Q	Q	Key indicator well for the 618-11 tritium plume[f]

[a] Frequency: A = annual; Q = quarterly; SA = semiannual. Frequency and analytes are based on PNNL (2000b) and the requirements of the 300-FF-5 SAP.
[b] The analytes identified include COCs from the DQO results plus general water quality parameters (e.g., pH) and markers (e.g., Iodine-129) needed to help interpret the data.
[c] VOA_8260a_RCRA analyses would report cis-1,2-dichloroethylene and trans-1,2-dichloroethylene individually, if total 1,2-dichloroethylene levels warrant it.
[d] RCRA program monitoring wells for the uranium and VOA plumes
[e] "Low Level" tritium method.
[f] These monitoring wells are generally located close to the suspected sources of the 300-FF-5 contaminant plumes and provide key information regarding near-field plume conditions.
[g] These monitoring wells are generally located near the downgradient boundaries of the 300-FF-5 contaminant plumes and provide key information regarding far-field plume conditions.
TBD = to be determined

Table 5-3. Seep and River Sample Locations.

New Site Name	Site Type	Current Use	Old Site Name	NAD83_East (m)	NAD83_North (m)
S1170	Seep	None	Spr-1	594,482.956	118,630.064
S1171	Seep	None	Spr-2	594,450.202	118,400.979
S1172	Seep	None	Spr-3	594,365.433	117,861.591
S1173	Seep	None	Spr-4	594,345.099	117,776.349
S1174	Seep	None	41-1	594,326.400	117,550.800
S1175	Seep	None	Spr-5	594,327.721	117,249.844
S1176	Seep	None	Spr-6	594,338.230	117,082.551
S1177	Seep	None	42-1	594,378.100	116,904.500
S1178	Seep	SESP	S300-42-2 (Spr-7)	594,392.078	116,696.501
S1179	Seep	None	Spr-8	594,467.539	116,289.940
S1180	Seep	SESP	S300-DR42-2 (Spr-9)	594,488.883	116,209.879
S1181	Seep	None	Spr-10	594,525.323	116,083.503
S1182	Seep	None	Spr-11	594,640.955	115,644.462
S1183	Seep	None	Spr-12	594,802.480	114,934.799
S1184	Seep	None	Spr-13	594,825.660	114,769.187
S1185	Seep	None	Spr-14	594,887.139	114,361.831
S1186	Seep	None	43-2	594,946.800	113,952.300
S1187	Seep	None	43-3	594,962.300	113,830.800
352	River	SESP	Rvr-300-10	595,469.880	114,898.900
471	River	None	Rvr-300-9	595,427.540	114,898.760
581	River	None	Rvr-300-8	595,378.660	114,897.120
351	River	SESP	Rvr-300-7	595,354.720	114,897.780
350	River	None	Rvr-300-6	595,312.800	114,897.750
607	River	SESP	Rvr-300-5	595,077.280	114,892.080
349	River	None	Rvr-300-4	595,030.150	114,892.520
580	River	SESP	Rvr-300-3	594,963.510	114,890.630
470	River	SESP	Rvr-300-2	594,895.780	114,890.730
348	River	SESP	Rvr-300-1	594,853.840	114,888.710
8240	River	SESP	Rvrshr-41.5	594,314.000	117,539.000
8241	River	SESP	Rvrshr-42.1	594,396.000	116,699.000
8242	River	SESP	Rvrshr-42.5	594,540.000	116,076.000
8243	River	SESP	Rvrshr-42.9	594,738.000	115,238.000

NOTE: See Figure B-2.

Table 5-4. Required Biota Monitoring Species/Locations.

Biota	Vernita[a]	Location 7[a] (S1178)	Location 9[a] (S1180)	Location 11[b] (S1182)	Location 14[b] (S1185)	Inclusion/Exclusion Justification
Terrestrial Species						
Great Basin Pocket mouse						Life history information indicates seep exposure/use not likely.
Darkling beetles						Life history information indicates seep exposure/use not likely.
Mayflies (adult)						Life history information indicates seep exposure/use not likely.
Sweet clover						Roots too shallow to access seep or near-shore groundwater.
Mulberry tree leaves	√	√	√			Tree roots deep enough to access groundwater. Good historical indicator of contamination.
Aquatic Species						
Crayfish						Few individual present at seep locations. Asian clam and sculpin are better choices
Prickly sculpin	√	√	√			Good integrator of contamination in environment. Present at key locations.
Asian clam	√	√	√			Good integrator of contamination in environment. Present at key locations.
Periphyton						Presence not consistent; greatly influenced by local substrate/ sediment conditions.

NOTE: Based on August 2001 PNNL/WDOH 300 Area seep investigation.
[a] Species monitoring recommended from this location.
[b] Seep flow inconsistent; not recommended for future monitoring.
√ = Species sampled from this location.

Table 5-5. Factors Influencing the Effectiveness of Natural Attenuation in 300-FF-5 Groundwater.

300-FF-5 Areas of Concern	COCs	Natural Attenuation Processes	Factors that Influence Process
300 Area complex	Uranium (total)	Precipitation, adsorption, dilution, dispersion	• Continued monitoring of existing system for trend analysis • Refinement of contaminant inventory in vadose zone • STOMP or PORFLO modeling for determination of rate of attenuation and restoration time frame • Groundwater/vadose zone parameters for model input • Correlate 300-FF-2 excavations to groundwater contaminant changes • Evaluation of near-river residual contamination in vadose zone with groundwater quality • Potential human/environmental exposure pathways at river interface
	Trichloroethylene, dichloroethylene, tetrachloroethylene, vinyl chloride	Degradation, dilution, dispersion	
	Strontium-90	Adsorption, radioactive decay, dilution, dispersion	
316-4/ 618-10	Uranium (total)	Adsorption, dilution, dispersion	• Removal of source • Expanded monitoring system • Determine tributyl phosphate influence on uranium transport • STOMP or PORFLO modeling for determination of rate of attenuation and restoration time frame • Groundwater/vadose zone parameters for model input
618-11	Tritium	Radioactive decay, dilution, dispersion	• Removal of source • Expanded monitoring system • STOMP or PORFLO modeling for determination of rate of attenuation and restoration time frame • Groundwater/vadose zone parameters for model input

Table 5-6. Analytical Methods, Detection Limits, and Precision and Accuracy Requirements for 300-FF-5 O&M Groundwater Monitoring.

COCs[a,b]	Survey/ Analytical Method[c]	CAS Number	Groundwater Preliminary Action Level	PQL	Precision Requirement	Accuracy Requirement
Nonradionuclides						
Trichloroethylene	SW846 8260 VOA	79-01-6	MTCA B 3.98 μg/L	5 μg/L	Per method	Per method
1,2-Dichloroethylene	SW846 8260 VOA	540-59-0	MCL 70 μg/L	5 μg/L	Per method	Per method
Tetrachloroethylene	SW846 8260 VOA	127-18-4	MTCA B 0.858 μg/L	5 μg/L	Per method	Per method
1,1-Dichloroethylene	SW846 8260 VOA	75-35-4	MCL 7 μg/L	5 μg/L	Per method	Per method
Vinyl chloride	SW846 8260 VOA	75-01-4	MCL 2 μg/L	10 μg/L	Per method	Per method
Nitrate[d]	SW846 9056 Anions	14797-55-8	MCL 10 mg/L	250 μg/L	Per method	Per method
Tributyl phosphate[d]	SW846 8270 SVOA	126-73-8	No standard; decomposes in water	100 μg/L	Per method	Per method
Radionuclides						
Tritium (H-3)	Separation – liquid scintillation counting	10028-17-8	MCL 20,000 pCi/L	400 pCi/L	±20%	70%-130%
Strontium-90	Separation – gas proportional counting	10098-97-2	MCL 8 pCi/L	2 pCi/L	±20%	70%-130%
Uranium (total)	Chemical – kenetic phosphorescence analysis	7440-61-1	MCL 30 μg/L	0.1 μg/L	±20%	70%-130%

[a] Total petroleum hydrocarbons and polyaromatic hydrocarbons will not be analyzed for unless VOAs indicate their presence.
[b] This table addresses only COCs. Field parameters (e.g., specific conductivity, dissolved oxygen, pH, reduction-oxidation potential) will be addressed in the SAP, as appropriate.
[c] All methods are suitable for biotic tissue analysis except for SW846 9056 anions (nitrate). If the laboratory is required to report biotic tissue values on a dry weight basis, the results may show elevated detection limits. This is because most biota samples are mainly water, and it is sometimes difficult to obtain enough raw material to yield a sufficient amount of solids to meet typical solid detection limits.
[d] These contaminants are not COCs, but are of interest as potential 300 Area plume tracers.

CAS = Chemical Abstract Services
MCL = maximum contaminant level (40 *Code of Federal Regulations* [CFR] 141.155 Subpart O, App. A)
MTCA = *Model Toxics Control Act*
PQL = practical quantitation limit
SMCL = secondary maximum contaminant levels (40 CFR 143.3)
SVOA = semivolatile organic analyte
VOA = volatile organic analyte

Table 5-7. Potential Uranium Treatment Technologies for Groundwater.

Technology	Description
Pump and treat	Hydraulic containment with some removal of contaminant mass. Adsorption studies would be useful in estimating potential mass removal effectiveness.
Soil flushing	Use a flushing solution to enhance extraction of the uranium with a pump-and-treat system. Different types of flushing solutions were tested as part of the uranium in soils integrated demonstration in the early 1990s. Candidate solutions may be considered from this work.
In situ reduction-oxidation manipulation	Uranium would be reduced in the barrier. The long-term stability of reduced uranium would need to be assessed because reduced uranium is more easily reoxidized than chromium.
In situ reactive barriers	Barriers such as Fe(0) may be applicable. There may also be some sorptive barriers that are applicable.
In situ stabilization	Use of phosphate, sulfide, supersaturated grout, and biological reduction for in situ stabilization are possibilities. Long-term stability is an issue. This technique could also be considered as "enhanced" natural attenuation where the stabilization reduces (but does not eliminate) the uranium release rate.

6.0 PROJECT MANAGEMENT

6.1 MAINTENANCE ACTIVITIES

Routine maintenance activities will be performed as described in the following sections.

6.1.1 Inspect and Repair Warning Signs and Fencing

Inspections shall be performed along the Columbia River to verify that warning signs identify the site as a restricted area and that the signs are upright and readable. Inspections shall be conducted at least once a year in conjunction with sampling activities and shall be documented in the field logbook. Inspections will be consistent with the requirements defined in the sitewide institutional control plan, which is currently being written.

6.1.2 Maintain Groundwater Monitoring Wells

Well maintenance may be required to ensure that groundwater monitoring wells remain fit for use. Maintenance may consist of inspection, camera survey, scrubbing, bailing, or redevelopment.

6.1.3 Repair, Calibrate, or Replace Equipment

This task will require periodic repair, replacement, or calibration of transducers, pumps, electric measuring tapes, steel measuring tapes, and supporting equipment (e.g., pH and specific conductance meters). Equipment shall be calibrated as required by the applicable DOE contractor procedure. Inspection will dictate the frequency of repair or replacement.

6.2 REPORTING REQUIREMENTS

Reviews of the 300-FF-5 data will be conducted after receipt of any groundwater, seep water, river water, or biota results at a 300 Area unit manager's meeting or specific data set briefings. Complete data sets and data evaluations will be provided to EPA in annual 300-FF-5 reports. Contingent on DOE, Richland Operations Office, and EPA CERCLA 5-year review needs, the 300-FF-5 monitoring information collected during each fiscal year could be included in PNNL's annual groundwater monitoring report or could be documented in annual stand alone 300-FF-5 reports. Regardless of the reporting format, the monitoring information (i.e., groundwater, seep, Columbia River, and biota data) for each fiscal year must be available to establish the next years' monitoring plan.

6.2.1 Annual Report

To facilitate the next EPA CERCLA 5-year review (in FY 2005), annual reports will be prepared summarizing the 300-FF-5 monitoring results and evaluating the effectiveness of MNA. The annual report will compile the data results, provide an interpretation and evaluation of all media monitored, and make recommendations regarding possible changes in the next years' monitoring needs (e.g., new sites or plumes, sites remediated, and new COCs).

For each plume or groundwater contamination area[1], the annual report will address the following key questions:

- Has the conceptual site model described in the O&M plan changed based on the new data collected?
- What wells were used to evaluate groundwater conditions for this plume?
- What is the estimated area of the plume (square meters) over the drinking water standard?
- Are natural attenuation processes resulting in a decrease in the areal extent of the plume? (A yes/no answer is required.)
- What conditions have changed in the last year (e.g., plume dimensions, groundwater concentrations, groundwater flow directions, changes in site conditions including the cleanup of nearby soil waste sites)?
- Are enhancements to the groundwater monitoring system recommended?
- What impacts have been observed in the shoreline monitoring data, including seeps, river, and other related biological receptors?
- Have these impacts been observed above "action" levels?

For each plume, the following will be included:

- A table of wells used for analysis will be presented along with maximum, minimum, average, and number of samples collected from each well.
- "Key indicator" wells used in the analysis will be identified and groundwater concentration data over time will be presented.

[1] 300 Area groundwater plumes addressed by 300-FF-5 OU: Uranium in the 300 Area, VOA plumes in the 300 Area (i.e., trichloroethylene, dichloroethylene, and tetrachloroethylene), strontium-90 plume, uranium/tributyl phosphate plume associated with the 618-10 Burial Ground/316-4 Cribs, and tritium plume associated with the 618-11 Burial Ground.

- A plan map will be included that designates plume contours, plots the location of wells used in the analysis of that plume, and identifies the area of the plume above the drinking water or cleanup standard. For the uranium plume in the 300 Area, the area of the plume greater than 90 μg/L should also be presented. Where appropriate, concentration trend plots will be included of "key" wells adjacent to plan map (similar to the historical maps in Appendix C).

6.2.1.1 Data Interpretation. The annual report will be structured such that the new annual data are added to all the previous information (i.e., existing monitoring results since 1996) in a "monitoring summary" section. In this way, data trends and movement toward (or away from) compliance (i.e., MCL and AWQC achievement or exceedence) can be easily derived. After a data quality assessment is performed, the data will be used to interpret groundwater conditions. Each annual report will address the MNA effectiveness evaluations presented in Section 5.7. Interpretive techniques may be incorporated in the annual report, including the following:

- **Hydrographs:** Water levels versus time may be graphed to determine decreases, increases, and seasonal or man-made fluctuations in groundwater levels.

- **Water table maps:** Water table elevations from multiple wells may be used to construct contour maps to estimate flow directions. Groundwater flow is assumed to be perpendicular to lines of equal potential.

- **Trend plots:** Concentrations of chemical or radiological constituents versus time may be graphed to determine increases, decreases, and fluctuations. Trend plots may be used in tandem with hydrographs and/or water table maps to determine if concentrations relate to changes in water level or groundwater flow directions.

- **Plume maps:** Distributions of chemical or radiological constituents may be mapped to document the source and extent of contamination. Changes in plume distribution over time may aid in determining plume movement and flow direction.

- **Contaminant ratios:** Contaminant ratios may sometimes be used to distinguish between different sources of contaminants.

6.2.2 Expanded Report in FY 2004

An expanded annual report will be written in FY 2004 and submitted to EPA in support of the next 5-year review in FY 2005. This expanded report must include the following:

- Evaluate the influence of source removal (i.e., remove-treat-dispose remedy) on groundwater quality

- Evaluate the impact of residual vadose zone contamination on groundwater quality

- Examine the plume geometry to determine whether high-concentration areas are shrinking, growing, or staying the same over time

- Reevaluate the COCs and well locations to ensure that all significant groundwater contamination sources have been identified and are being monitored
- Evaluate K_d values for all COCs, as appropriate
- Determine horizontal and vertical extent of COCs. If any new wells are drilled, the vadose soils will be sampled as the wells are drilled to determine vertical extent of COCs
- Evaluate trend plots of contaminant and predicted degradation product concentrations to determine if the COCs are behaving consistently with predicted natural attenuation scenarios
- Update existing site conceptual contaminant fate and transport models, or develop new models to predict attenuation rates, as necessary
- Consider additional remedial actions if MNA is determined to be ineffective
- Consider a technical impracticability waiver under CERCLA if none of the remedial alternatives prove practicable.

6.3 RCRA/CERCLA INTEGRATION

The Tri-Party Agreement (Ecology et al. 1998) addresses CERCLA, RCRA, and Washington's dangerous waste program (WAC 173-303 [the state's RCRA equivalent]) implementation at the Hanford Site. The EPA is the Federal agency responsible for the oversight of DOE's implementation of CERCLA. The CERCLA program is implemented via 40 *Code of Federal Regulations* (CFR) 300, "National Oil and Hazardous Substances Pollution Contingency Plan," which establishes procedures for characterization, evaluation, and remediation. Ecology is responsible for oversight of DOE's implementation of RCRA, under the authority of the state's dangerous waste program. For purposes of the RCRA and WAC 173-303, the Hanford Site is considered a single facility that encompasses more than 70 treatment, storage, and disposal units. Ecology issued the Hanford Facility RCRA Permit (#WA7890008967) dangerous waste portion that has been in effect since September 1994.

There is significant overlap between the RCRA corrective action program and CERCLA. In addition, many waste management units are subject to remediation under both programs. There are several remediation activities underway at the Hanford Site (such as remedial investigation and cleanup in the 300 Area) that are accomplished using the CERCLA process. According to the 1999 annual report (PNNL 2000b), groundwater samples collected from monitoring wells in the 300 Area were analyzed for a variety of dangerous waste constituents and site-specific constituents, including selected radionuclides. The contaminant lists meet the minimum RCRA regulatory requirements and are integrated to supplement other groundwater project requirements (i.e., CERCLA) at the Hanford Site.

6.4 CHANGE MANAGEMENT PROCEDURES

The project manager is responsible for tracking all changes and obtaining appropriate technical reviews. The project manager will discuss changes with DOE, and DOE will then discuss necessary changes with the EPA. The lead regulatory agency (i.e., EPA) is responsible for determining the significance of the change and informing Ecology, as appropriate. Appropriate documentation will be developed based on the type of change. A suggested format for minor changes is shown in Figure 6-1.

6.5 INTEGRATION WITH SOIL CLEANUP EFFORTS

Any pertinent data collected through this O&M plan will be integrated with soil cleanup efforts. The monitoring data could be used in support of waste site remediation; specifically, CVPs. Similarly, if additional significant COCs are discovered during waste site remediation, the monitoring plan will be modified accordingly.

6.6 QUALITY ASSURANCE/QUALITY CONTROL REQUIREMENTS

Quality assurance for sampling and analysis activities will follow the most current applicable DOE contractor requirements. The requirements and guidelines for sample collection and analysis to support this O&M plan shall meet the regulatory requirements as defined in RCRA; CERCLA; and the *Revised Code of Washington*, "Hazardous Waste Management Act" (RCW 70.105), as delineated in the Tri-Party Agreement (Ecology et al. 1998). The quality assurance project plan in the SAP will be prepared in accordance with *Hanford Analytical Services Quality Assurance Requirements Documents*, Volumes 1, 2, 3, and 4 (DOE-RL 1998).

6.7 WASTE MANAGEMENT

A waste management plan exists for the 300-FF-5 OU (DOE-RL 2000c). This plan establishes the requirements for the management and disposal of waste generated from the groundwater wells used to monitor the 300-FF-5 OU, as required by the ROD (EPA 1996). This waste management plan will be revised as necessary to address seep water, Columbia River water, and biota sampling efforts.

6.8 DATA MANAGEMENT

The contract laboratories report analytical results electronically. The results are loaded into the HEIS database. Field-measured parameters are entered manually or through electronic transfer. Paper data reports and field records are considered to be the record copies and are stored with the appropriate contractor.

Once the data have been reported, they will undergo a verification process according to CERCLA requirements. Quality control data are evaluated against the criteria listed in the project quality assurance plan, and data flags are assigned when the data do not meet those criteria. In addition, the data are screened by scientists familiar with the local hydrogeology, compared to historical trends or spatial patterns, and flagged if they are not representative. If sample results are not representative, analysis calculations are checked, samples may be reanalyzed, or a new sample may be collected and analyzed.

Figure 6-1. Suggested Format to Document Minor Changes to the 300-FF-5 O&M Plan.

Modification Form for the 300-FF-5 O&M Plan

Modification:

Justification for Modification:

Originator	Date
Approval	Date
DOE/RL	Date
EPA	Date

7.0 MONITORING AND DELIVERABLE ACTIVITIES

7.1 DECISION TIMELINE

The O&M plan activities for the 300-FF-5 OU planned for calendar years 2002 through 2006 are summarized in Table 7-1. These monitoring and deliverable activities will be reviewed/revised annually (as appropriate) to ensure that 300-FF-5 data and MNA evaluation requirements are being addressed.

7.2 FUTURE ACTIONS TO BE CONSIDERED

This section presents a discussion of future actions that might be needed to evaluate ROD compliance. Each of these actions will need to be addressed through annual detailed work planning or the baseline change proposal process.

The fuel oil bunkers (designated as 300-6 in the Waste Information Data System) could be added as an area of concern to this O&M plan if contamination is discovered in groundwater during the FY 2002 characterization of the bunker excavation and associated local groundwater. Excavation of the fuel tank and contaminated soil to 4 m (15 ft) below ground surface was completed during FY 2001.

The vertical extent of 300-FF-5 COCs in groundwater is not well known. Contaminant concentrations for samples collected at regular intervals during 300 Area new well or borehole drillings would contribute to the understanding of the vertical extent of 300-FF-5 COCs. Data obtained from new wells will be considered in revisions to the SAP or through the change management process as described in Section 6.4.2.

Contaminant fate and transport is not well known for the COCs. Fate and transport models could be constructed and may require additional K_d/leachability testing.

Table 7-1. Sampling and Deliverable Schedule for 300-FF-5 (3 Pages)

Month	Samples Required for 300-FF-5 Monitoring							Monitoring Deliverables/Activities								Comments
	Groundwater Wells (near River)	Groundwater Wells (inland)	Columbia River Water	Seep Water	Aquifer Tubes	River/Seep Biota	River Seep Sediment	Data Summary	Draft Report	Next FY SAP Plan	Final Report	Approve SAP	Initiate Modeling Effort	Initiate 5-Year Review	Consider Alternate Actions	
FY 2001																
June																
July																
August			X[ab]	X[ab]	X[ab]	X[ab]	X[ab]									WDOH/PNNL 300 Area shoreline sampling
September																
FY 2002																
October																
November																
December		X[c]														
January																
February								X[d]			X[e]					
March		X[c]							X[d]			X				FY02 SAP scheduled for approval by 3/29/02
April										X[f]	X[d]					Results required by 4/1 to plan for next monitoring cycle
May										X[f]			X			Scope/budget modeling needs to assess MNA compliance
June	X[g]	X[cg]														
July																
August																
September	X[a]	X[c]	X[a]	X[a]	X[a]	X[a]	X[a]									
FY 2003																
October													X			Monitoring data assembly; begin modeling assessment of MNA compliance
November																
December		X[c]						X[d]								
January									X[d]							
February											X[e]					
March		X[c]									X[h]					
April										X[f]						Results required by 4/1 to plan for next monitoring cycle
May										X[f]						
June	X[g]	X[cg]										X				DOE and EPA SAP approval needed before next monitoring cycle starts
July																
August																
September	X[a]	X[c]	X[a]	X[a]	X[a]	X[a]	X[a]									

Table 7-1. Sampling and Deliverable Schedule for 300-FF-5 (3 Pages)

Month	Samples Required for 300-FF-5 Monitoring							Monitoring Deliverables/Activities								Comments
	Groundwater Wells (near River)	Groundwater Wells (inland)	Columbia River Water	Seep Water	Aquifer Tubes	River/Seep Biota	River Seep Sediment	Data Summary	Draft Report	Next FY SAP Plan	Final Report	Approve SAP	Initiate Modeling Effort	Initiate 5-Year Review	Consider Alternate Actions	
FY 2004																
October														X		Initiate technical evaluation to support EPA CERCLA 5-year review.
November																
December								X[d]								
January									X[di]							
February											X[ei]					
March											X[hi]					
April										X[f]						Results required by 4/1 to plan for next monitoring cycle
May										X[f]						
June	X[g]	X[g]										X				DOE and EPA SAP approval needed before next monitoring cycle starts
July																
August																
September	X[a]		X[a]	X[a]	X[a]	X[a]	X[a]									
FY 2005																
October															X	
November																
December								X[d]								
January									X[d]							
February											X[e]					
March											X[h]					
April										X[f]						Results required by 4/1 to plan for next monitoring cycle
May										X[f]						
June	X[g]	X[g]										X				DOE and EPA SAP approval needed before next monitoring cycle starts
July																
August																
September	X[a]		X[a]	X[a]	X[a]	X[a]	X[a]									
FY 2006																
October																If MNA ineffective; consider ACLS or technical impracticability in FS report?
November																
December								X								
January									X							

Table 7-1. Sampling and Deliverable Schedule for 300-FF-5 (3 Pages)

Month	Samples Required for 300-FF-5 Monitoring							Monitoring Deliverables/Activities								Comments
	Groundwater Wells (near River)	Groundwater Wells (inland)	Columbia River Water	Seep Water	Aquifer Tubes	River/Seep Biota	River Seep Sediment	Data Summary	Draft Report	Next FY SAP Plan	Final Report	Approve SAP	Initiate Modeling Effort	Initiate 5-Year Review	Consider Alternate Actions	
February											X[e]					Next monitoring cycle plan contingent on MNA evaluation results
March											X[h]					
April										X[fj]						Results required by 4/1 to plan for next monitoring cycle
May										X[fj]						
June	X[g]	X[g]										X				DOE and EPA SAP approval needed before next monitoring cycle starts
July																
August																
September	X[a]		X[a]	X[a]	X[a]	X[a]	X[a]									

[a] Low Columbia River discharge period (depending on year, actual sample dates could be in August, September, or October.
[b] This FY 2001 sampling effort satisfies the requirements for reporting/planning for FY2002.
[c] New 618-11 and 618-10 monitoring wells are to be sampled quarterly for the first two years to establish a water quality baseline.
[d] Biota/seep/river/sediment results/reports.
[e] PNNL annual groundwater report is issued by end of February for previous fiscal year.
[f] Review previous fiscal year SAP; scope/schedule/budget planning for next monitoring cycle.
[g] High Columbia River discharge period (depending on year, actual sample dates could be in May, June, or July) .
[h] Letter report for biota/seep/river/sediment information.
[i] 2004 reporting effort will be expanded to include MNA compliance assessment results; establish basis for CERCLA 5-Year Review by EPA in 2005.
[j] As appropriate, incorporate 5-Year Review findings into monitoring plan.

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APPENDIX A

300-FF-5 OPERATION AND MAINTENANCE PLAN REVISION DATA QUALITY OBJECTIVES SUMMARY REPORT

TABLE OF CONTENTS

TABLES

ACRONYMS

AA	alternative action
ARAR	applicable or relevant and appropriate requirement
AWQC	ambient water quality criteria
BHI	Bechtel Hanford, Inc.
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CHI	CH2M Hill Hanford, Inc.
COC	contaminant of concern
COPC	contaminant of potential concern
DOE	U.S. Department of Energy
DQO	data quality objective
DR	decision rule
DS	decision statement
Ecology	Washington State Department of Energy
ENW	Energy Northwest
EPA	U.S. Environmental Protection Agency
ERC	Environmental Restoration Contractor
ESD	explanation of significant difference
FY	fiscal year
LBGR	lower bound of gray region
MCL	maximum contaminant level
MNA	monitored natural attenuation
O&M	operations and maintenance
OU	operable unit
PCB	polychlorinated biphenyl
PNNL	Pacific Northwest National Laboratory
PQL	practical quantitation limit
PSQ	principal study question
RCRA	*Resource Conservation and Recovery Act of 1976*
RL	U.S. Department of Energy, Richland Operations Office
ROD	Record of Decision
SAP	sampling and analysis plan
UCL	upper confidence level
WDOH	Washington State Department of Health

A1.0 STEP 1 – STATE THE PROBLEM

The purpose of this data quality objective (DQO) summary report is to support decision-making activities as they pertain to 300-FF-5 Operable Unit (OU) groundwater monitoring and evaluation requirements. The objective of DQO Step 1 is to clearly state the problems to be resolved using the information gathered during the scoping process.

A1.1 PROJECT OBJECTIVES

This DQO effort addresses the data needed to address four items of concern and identifies the groundwater monitoring and evaluation approaches for consideration for the revision of the *Operation and Maintenance Plan for the 300-FF-5 Operable Unit* (DOE/RL-95-73, Rev. 0 [DOE-RL 1996]). The four items of concern are as follows:

- Expansion of the OU boundary.
- New 300 Area groundwater contamination was identified.
- Heightened concerns about contaminated groundwater entering the Columbia River in the 300 Area (water quality and biological concerns at the river springs).
- Evaluation needs regarding the effectiveness of monitored natural attenuation (MNA) as the selected remedial alternative for the 300-FF-5 OU.

The operations and maintenance (O&M) plan revision must address the issues identified in the 5-year *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) Record of Decision (ROD) review (EPA 2001) and the OU boundary changes documented in the June 2000 explanation of significant difference (ESD) (EPA et al. 2000).

A1.2 PROJECT ASSUMPTIONS

Project assumptions for this DQO process include the following:

1. The updated 300-FF-5 O&M plan will retain some of the aspects of the current plan (DOE-RL 1996).
2. The O&M plan update will address groundwater/river seep monitoring needs (i.e., wells, plumes, and contaminants of concern [COCs]), potential adverse effects from groundwater/seep discharges to the Columbia River (biological sampling), and the effectiveness of MNA on 300 Area groundwater contamination.

3. The O&M plan will not include monitoring plumes entering the 300 Area (i.e., originating in the 100 and 200 Areas); however, 300-FF-5 monitoring wells may include analysis of the 100 and 200 Area COCs.

4. The monitored area will include all groundwater beneath the 300-FF-2 OU.

5. The areas of concern for 300-FF-5 monitoring will include specific locations and also general areas:

   - The plume associated with the 618-11 Burial Ground
   - The plume associated with the 618-10 Burial Ground and 316-4 Crib
   - The plume located in the vicinity of well 399-3-10
   - The plume associated with the 300-FF-1 and 300-FF-2 OU
   - The "seeps" entering the Columbia River adjacent to the 300-FF-2 OU.

6. The updated O&M plan will require the installation of additional new monitoring wells, and additional COCs will be added (contingent on recent remedial investigation/feasibility study activities in the 300 Area [DOE-RL 2000]).

7. The MNA for groundwater remediation would be considered successful if it achieves the minimum contaminant level or ambient water quality criteria (AWQC) concentration compliance prior to human or ecological receptor exposure locations (i.e., the Columbia River/groundwater interface), and/or a downward/stable COC concentration trend is established through ongoing monitoring data and/or computer modeling estimates.

8. This DQO effort will be entirely "external," as the U.S. Environmental Protection Agency (EPA), the Washington State Department of Ecology [Ecology], and the Washington State Department of Health (WDOH) will be involved throughout the process. (This effort will not follow the typical internal/external model used for most Environmental Restoration Contractor [ERC] processes).

A1.3 PROJECT ISSUES

A1.3.1 Global Issues

One global issue was identified for this project. A single groundwater monitoring plan that would satisfy CERCLA and *Resource Conservation and Recovery Act of 1976* (RCRA) needs would be preferred by the decision makers. However, because of legal requirements and restrictions, this single plan may not be possible, and EPA and Ecology representatives are working on a solution.

A1.3.2 Task-Specific Technical Issues and Resolutions

The task-specific technical issues and resolutions are as follows:

1. Current 300-FF-5 O&M plan groundwater COCs include only total uranium, trichloroethylene, and cis-1, 2-dichloroethene. Additional groundwater contaminants have been identified.

   Issue #1: EPA wants to add tetrachloroethylene and strontium-90 (general 300 Area), tributyl phosphate (316-4 Crib/618-10 Burial Ground sources), tritium (618-11 Burial Ground source), technetium-99 (plume entering from southwest), and possibly other contaminants (identified during 300 Area source site remedial action) to the 300-FF-5 groundwater COC list.

2. The current groundwater monitoring network is composed of existing wells distributed throughout the 300 Area. The wells are sampled annually during Columbia River low-flow periods in August and September). The existing wells do not cover the 618-11 or 618-10 Burial Ground or 316-4 Crib areas of concern and may not be sufficient to address the effectiveness of MNA as a groundwater remedial treatment.

   Issue #2: EPA believes that the current monitoring well network is inadequate to demonstrate effective groundwater plume attenuation (by physical or biological processes to achieve drinking water standards) or to evaluate the need for active response measures. Additional downgradient wells will likely be required to address the plumes now associated with the 300-FF-5 OU (i.e., the 300-FF-1 geographic area, 618-11 site, and 618-10/ 316-4 site). Groundwater, near- river seep water, and Columbia River biological data evaluations are needed to assess the effectiveness of MNA as the selected remedial action.

3. Columbia River sampling results from 1999 indicated that the average annual uranium concentrations at Priest Rapids Dam (upriver, Hanford control) and the Richland water intake (down river from Hanford) were not statistically different; therefore, no Hanford influence is made on water quality.

   Issue #3: EPA does not believe that this determination can be applied to the 300 Area seeps that discharge to the Columbia River. The updated O&M plan should include environmental monitoring associated with the contaminated groundwater discharges to the Columbia River from the 300 Area seeps.

4. Monitoring the tritium plume near the 618-11 Burial Ground will require coordination and access to Energy Northwest (ENW) areas. The presence of buildings, other ENW facilities, and ENW activities could influence groundwater monitoring locations and the overall success of the monitoring.

   Issue #4: ERC and the decision makers will work with ENW to ensure that the 618-11 Burial Ground tritium plume monitoring effort is adequate to support the O&M plan goals.

A1.4 EXISTING REFERENCES

Table A1-1 presents a list of the references reviewed as part of the scoping process and a summary of the information contained within each reference. These references are the primary source for the background information presented in Section 1.5.

Table A1-1. Existing References.

Reference	Summary
Explanation of Significant Difference (ESD) for the 300-FF-5 Record of Decision (EPA et al. 2000)	Documents changes in the 1996 ROD for the 300-FF-1 and 300-FF-5 OUs, provides OU background information, and describes current groundwater monitoring efforts.
Operation and Maintenance Plan for the 300-FF-5 Operable Unit, DOE/RL-95-73, Rev. 0 (DOE-RL 1996)	Documents background conditions and presents operation, maintenance, monitoring, and reporting requirements for the 300-FF-5 OU.
Phase I and II Feasibility Study for the 300-FF-1 Operable Unit, DOE/RL-92-46, Rev. 0 (DOE-RL 1993)	Summary of site history, contaminants present, risk assessment results, and remedial action options for liquid waste sites influencing 300-FF-5 groundwater.
Focused Feasibility Study for the 300-FF-2 Operable Unit, DOE/RL-99-40, Rev. 0 (DOE-RL 2000)	Summary of site history, contaminants present, risk assessment results, and remedial action options for solid waste sites influencing 300-FF-5 groundwater.
USDOE Hanford Site First Five-Year Review Report (EPA 2001)	Documents the conclusions from the 1996 ROD for the 300-FF-5 OU. Presents EPA's evaluation of the remedy goals, remedy implementation, and remedy completeness. Presents action items required for the OU.
Annual (1996 through 1999) groundwater monitoring reports (PNNL-11470, PNNL-11793, PNNL-12086, and PNNL-13116) (PNNL 1997, 1998, 1999, 2000)	Summary of groundwater monitoring results (e.g., sampling and analysis methods and analytical data).
Remedial Investigation/Feasibility Study Report for the 300-FF-5 Operable Unit, DOE/RL-94-85, Rev. 0 (DOE-RL 1995)	Evaluation of 300-FF-5 contamination and assessment of remedial actions.

A1.5 SITE BACKGROUND INFORMATION

A concise summary of 300-FF-5 background information, including source site descriptions, site histories, and an ESD from the original 300-FF-5 ROD (and O&M plan) are presented in the ESD for the 300-FF-5 ROD (EPA et al. 2000).

The available analytical results for the 300-FF-5 monitoring effort are summarized in the Hanford Site groundwater monitoring documents for 1996 through 1999 (PNNL 1997, 1998, 1999, 2000).

A1.6 DATA QUALITY OBJECTIVE TEAM MEMBERS AND KEY DECISION MAKERS

Members of the project team were selected to participate in the DQO process based on their expertise in the technical areas needed to meet the task objectives. The key decision makers include representatives from the U.S. Department of Energy (DOE), Richland Operations Office (RL); Ecology; WDOH; and EPA. Tables A1-2 and A1-3 identify the members of the DQO team and the decision makers.

Table A1-2. DQO Team Members.

Name	Organization	Role and Responsibility
Kim Anselm	CHI Office Services	Project Assistant/Document Control
Janet Badden	CHI Regulatory Support	Regulatory Compliance
Jane Borghese	CHI Geosciences and Engineering	Project Engineer and Waste Management
Mike Faurote	CHI Geosciences	Geology
Larry Hulstrom	CHI Environmental Engineering	Scoping – Existing Conditions
Chantill Kahler-Royer	CHI Design Engineering	O&M Plan Author
Chris Koerner	CHI Project Controls	Cost Controls
Jon Lindberg	PNNL	Groundwater Monitoring/Sampling
Bill McMahon	CHI Geosciences	Scoping – Data Needs
Roger Ovink	CHI Remediation Processes	DQO Facilitator/Author
Jim Sharpe	CHI Environmental Services	Cultural/Natural Resources
Shelley Switzer	CHI Office Services	Project Assistant/Document Control
Rich Weiss	CHI Sample/Data Management	Analytical-Laboratory
Joan Woolard	BHI Regulatory Support	Environmental Lead and Waste Management
Chris Wright	CHI Geosciences	Scoping – Data Needs

BHI = Bechtel Hanford, Inc.
CHI = CH2M Hill Hanford, Inc.
PNNL = Pacific Northwest National Laboratory

Table A1-3. Decision Makers.

Name	Organization	Role and Responsibility
Bob McLeod	RL	300-FF-2 Project Lead
Dick Jaquish	WDOH	Health Expert; Advisor to EPA
John Price	Ecology	Ecology Representative; Advisor to EPA
Mike Goldstein	EPA	EPA Project Lead (Lead Agency)
Mike Thompson	RL	Groundwater Project Lead

A1.7 PROJECT BUDGET AND CONTRACTUAL VEHICLES

Table A1-4 presents the budgets for the activities associated with the project and the available contractual vehicles for subcontractors.

Table A1-4. Task Budget and Contractual Vehicles.

Task Activities	Budget	Contractual Vehicle
DQO workbook development	$64,910	ERC scope
SAP development	TBD based on DQO	N/A
Field implementation	TBD based on DQO	
Laboratory analyses	TBD based on DQO	
Data quality assessment	TBD based on revised O&M plan	
Documentation of investigation results	TBD based on revised O&M plan	

N/A = not applicable
SAP = sampling and analysis plan
TBD = to be determined

A1.8 MILESTONE DATES

Table A1-5 presents the milestone dates for the completion of all task activities associated with the development and implementation of the sampling program, the performance of laboratory analyses, the performance of a data quality assessment, and the evaluation and reporting of investigation results.

Table A1-5. Milestone Dates.

Task Activities	Milestone Date
DQO workbook development	December 2000 through February 2001
300-FF-5 O&M plan development	January through March 2001
Field implementation/laboratory analyses	FY 2001 through FY 2006 (monitoring)
Documentation of investigation results	FY 2001 through FY 2006 (annual reports)

FY = fiscal year

A1.9 CONTAMINANTS OF CONCERN

A list of COCs for the 300-FF-5 OU was generated by listing all the contaminants of potential concern (COPCs) based on historical operations and analytical results as documented in the *Phase I and II Feasibility Study for the 300-FF-1 Operable Unit* (DOE-RL 1993) and the *Focused Feasibility Study for the 300-FF-2 Operable Unit* (DOE-RL 2000). Certain COPCs were removed if they have a short half-life, are not regulated, pose no risk, or are non-toxic or if process knowledge/analytical data confirm that insignificant releases have occurred.

A1.9.1 Total List of Contaminants of Potential Concern

Table A1-6 identifies all of the COPCs for the media of concern.

Table A1-6. Total List of COPCs for Each Media Type. (2 Pages)

Media	Known/ Suspected Contamination Source	Contamination Type (General)	COPCs (Specific)
Groundwater, surface water, biota (aquatic or terrestrial)	Construction or demolition debris and liquid waste disposal/spills	Metals and other inorganics	Aluminum, antimony, arsenic, asbestos, barium, beryllium, bismuth, cadmium, chromium, cobalt, copper, iron, lead, mercury, nickel, selenium, silicon, silver, tin, vanadium, zinc, zirconium
		Acids/bases	Chromic acid, formic acid, hydrocyanic acid, hydrofluoric acid, nitric acid, oxalic acid, phosphoric acid, sulfuric acid, sodium aluminate, sodium dichromate, sodium hydroxide, sodium nitrate, sodium silicate
		Semi-volatile organics	PCBs, petroleum hydrocarbons, tributyl phosphate

Table A1-6. Total List of COPCs for Each Media Type. (2 Pages)

Media	Known/ Suspected Contamination Source	Contamination Type (General)	COPCs (Specific)
		Volatile organics	Benzo (a) pyrene, vinyl chloride, total 1,2-dichloroethylene, 1,1-dichloroethylene, 1,1,1-trichloroethane, acenaphthene, acetone, benzene, carbon tetrachloride, chloroform, ethylene glycol, formaldehyde, methanol, methylene chloride, methyl ethyl ketone, hexone, tetrachloroethylene, trichloroethylene, toluene, xylene.
		Radionuclides	Americium-241, curium-244, curium-242, neptunium-237, plutonium-239/240, uranium-234/235 or uranium-238, thorium-227, thorium-228, thorium-230, thorium-231, thorium-232, strontium-90, cesium-137, cobalt-60, europium-152, europium-154, europium-155, tritium (H-3), niobium-94, ruthenium-106, technetium-99, zirconium-93

PCB = polychlorinated biphenyl

A1.9.2 Contaminants of Potential Concern Addressed by Concurrent Remediation Activities

The scope of a DQO summary report prepared to support remediation activities typically assumes the responsibility for all media at the site. However, if media and associated COPCs are already addressed by concurrent activities (i.e., under a separate sampling and analysis plan [SAP] or waste management plan), the COPCs may be excluded from further consideration in this DQO process. Table A1-7 presents a list of the COPCs that are being removed from the total list of COPCs for this reason.

Table A1-7. COPCs Addressed by Concurrent Remediation Activities.

Media	COPCs	Remediation Activity
Soil and debris	All noted in Table A1-6	Removal/treatment/disposal for all liquid disposal and burial grounds in the 300-FF-5 OU area (300-FF-1 and 300-FF-2 surface OUs).

A1.9.3 Other Contaminant of Potential Concern Exclusions

Table A1-8 presents a list of all other COPCs to be excluded from the investigation (in addition to the Table A1-7 exclusions) based on physical laws, process knowledge, task focus, or other mitigating factors. Table A1-8 also provides the specific rationale for the COPC exclusions for all media. The excluded COPCs below are not believed to be required to address purgewater waste disposition tanks.

Table A1-8. Rationale for COPC Exclusions.[a] (4 Pages)

COPC	Rationale for Exclusion
Acids/bases	There are no standard laboratory methods for these specific acids and bases. As a general water quality parameter, pH would be part of the analyte list as a general water parameter.
PCBs	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Petroleum hydrocarbons (including oil and grease)	Not identified in previous groundwater monitoring efforts at levels exceeding MCLs for 618-11 or the 300-FF-1 and 300-FF-2 areas of concern. May be included as a COC if the 384 Fuel Bunker is found to have contaminated groundwater.
Aluminum	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Antimony	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Arsenic	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Asbestos	Not expected in water/biota at elevated levels.
Barium	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Beryllium	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Bismuth	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Cadmium	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Chromium (trivalent and hexavalent)	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Cobalt	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Copper	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Iron	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Lead	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Mercury	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Nickel	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Selenium	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.

Table A1-8. Rationale for COPC Exclusions.[a] (4 Pages)

COPC	Rationale for Exclusion
Silicon	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Silver	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Tin	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Vanadium	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Zinc	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Zirconium	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Benzo (a) pyrene	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
1,1,1-trichloroethane	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Acenaphthene	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Acetone	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Benzene	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Carbon tetrachloride	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Chloroform	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Ethylene glycol	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Formaldehyde	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Methanol	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Methylene chloride	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Methyl ethyl ketone	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Hexone	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Tetrachloroethylene	Partial exclusion: not identified in previous groundwater monitoring efforts at levels exceeding MCLs for the 618-11 or 618-10 Burial Grounds or 316-4 Crib areas of concern.

Table A1-8. Rationale for COPC Exclusions.[a] (4 Pages)

COPC	Rationale for Exclusion
Trichloroethylene	Partial exclusion: not identified in previous groundwater monitoring efforts at levels exceeding MCLs for the 618-11 or 618-10 Burial Grounds or 316-4 Crib areas of concern.
1, 2-dichloroethylene	Partial exclusion: not identified in previous groundwater monitoring efforts at levels exceeding MCLs for the 618-11 or 618-10 Burial Grounds or 316-4 Crib areas of concern.
Toluene	Partial exclusion: not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Tributyl phosphate	Partial exclusion: not identified in previous groundwater monitoring efforts at levels exceeding MCLs for the 618-11 Burial Ground or 300-FF-1 and 300-FF-2 areas of concern.
Xylene	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Americium	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Curium	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Neptunium	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Plutonium	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Uranium-234/235	Isotopic uranium concentrations are not required for the current effort. Total uranium is required.
Uranium-238	Isotopic uranium concentrations are not required for the current effort. Total uranium is required.
Thorium	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Strontium-90	Partial exclusion: not identified in previous groundwater monitoring efforts at levels exceeding MCLs for the 618-11 or 618-10 Burial Grounds or 316-4 Crib areas of concern.
Carbon-14	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Cesium-137	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Cobalt-60	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Europium-152, -154, and -155	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Iodine-129	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Technetium-99	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.

Table A1-8. Rationale for COPC Exclusions.[a] (4 Pages)

COPC	Rationale for Exclusion
Nickel-63	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Niobium	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Ruthenium-106	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.
Zirconium	Not identified in previous groundwater monitoring efforts at levels > MCLs for any 300-FF-5 areas of concern.

[a] The excluded COPCs apply to all media.
MCL = maximum contaminant level

A1.9.4 Final List of Contaminants of Concern

Table A1-9 presents the final list of COCs for each media to be carried through the remainder of the DQO process.

Table A1-9. Final List of COCs.[a]

Media	COCs
Surface water	<u>300-FF-1 and 300-FF-2 area of concern</u>: Trichloroethylene, total 1,2-dichloroethylene, 1,1-dichloroethylene, vinyl chloride, tetrachloroethylene, uranium (total), and strontium-90
Seep water and associated sediment	<u>300-FF-1 and 300-FF-2 area of concern</u>: Trichloroethylene, total 1,2-dichloroethylene, 1,1-dichloroethylene, vinyl chloride, tetrachloroethylene, uranium (total), and strontium-90
Biota (tissue)[b]	<u>300-FF-1 and 300-FF-2 area of concern</u>: Uranium (total) and strontium-90
Groundwater	<u>300-FF-1 and 300-FF-2 area of concern</u>: Trichloroethylene, total 1,2-dichloroethylene, 1,1-dichloroethylene, vinyl chloride, tetrachloroethylene, uranium (total), and strontium-90 <u>618-11 Burial Ground area of concern</u>: Tritium and uranium (total) <u>618-10 Burial Ground and 316-4 Crib area of concern</u>: Tritium and uranium (total) <u>384 Fuel Bunker Tank area of concern</u>: Petroleum hydrocarbons[c]

[a] This table documents COCs only; field parameters, general water quality parameters, and possible groundwater plume indicators (e.g., pH, Eh, specific conductivity, inductively coupled plasma metals, and anions) are considered separately. COCs are based on lists presented in EPA (1996b, 2000, 2001) and DOE-RL (2001). Additional discussions were held during development of the DQO process, as reported in Appendix A of the 300-FF-5 O&M Plan (DOE-RL 2002).
[b] While volatile organic analytes are anticipated in other media, they are not expected in biota (tissue).
[c] Petroleum hydrocarbons will be included as a COC in the SAP only if the fuel bunker is found to have contaminated the groundwater.

A1.9.5 Distribution of Contaminants of Concern

Table A1-10 identifies the best understanding of how each of the COCs arrived at the site and the fate and transport mechanisms (e.g., wind or water) that may have influenced COC distribution.

Table A1-10. Distribution of COCs.

Media	COCs	How COC Arrived at Site	Fate and Transport Mechanisms	Expected Distribution (Heterogeneous/ Homogeneous)
Groundwater	All	Construction or demolition debris and liquid waste disposal/spills	Leached from waste and contaminated vadose soils	Homogeneous within each plume (COC concentrations variable due to dilution)
Surface water		Same as groundwater	Groundwater transport to shoreline seeps and then to the Columbia River	Homogeneous within affected river areas (COC concentrations seasonally variable due to bank storage water dilution)
Seep water		Same as groundwater	Groundwater transport to shoreline seeps	Homogeneous within each seep (COC concentrations seasonally variable due to bank storage water dilution)
Biota (aquatic)		Same as groundwater	Groundwater and shoreline seeps to Columbia River vegetation and wildlife	Heterogeneous within plants (e.g., roots, stems, and leaves) and animals (e.g., organs, muscle, and fat)
Biota (terrestrial)		Same as groundwater	Groundwater and shoreline seeps to riparian zone (shoreline) vegetation and wildlife	Heterogeneous within plants (e.g., roots, stems, and leaves) and animals (e.g., organs, muscle, and fat)

A1.10 CURRENT AND POTENTIAL FUTURE LAND USE

The current and potential future uses for the land in the immediate vicinity of the site under investigation are summarized in Table A1-11. This information is needed later in the DQO process to support the evaluation of decision error consequences.

Table A1-11. Current and Potential Future Land Use.

Current Land Use	Potential Future Land Use
DOE-managed, restricted public access	Industrial

A1.10.1 PRELIMINARY ACTION LEVELS

The preliminary action levels that apply to each of the COCs are presented in Table A1-12 with the basis for each level. The action level is defined as the threshold value that provides the criterion for choosing between alternative actions (AAs). The action levels presented in Table A1-12 are based on waste acceptance criteria from the disposal site, regulatory thresholds, and/or risk. The final numerical action level will be set in DQO Step 5.

Table A1-12. List of Preliminary Action Levels.

Media	COCs	Preliminary Action Level	Basis
Groundwater	See Table A1-9	Drinking water MCLs	EPA and Ecology ARARs
Surface water		Drinking water MCLs and AWQC	EPA and Ecology ARARs
Seep water		AWQC	EPA and Ecology ARARs
Biota (aquatic) tissue		Exposed tissue levels significantly greater than background (control) tissue concentrations	Exposed versus background tissue comparisons
Biota (terrestrial) tissue		Exposed tissue levels significantly greater than background (control) tissue concentrations	Exposed versus background tissue comparisons

ARAR = applicable or relevant and appropriate requirement

A1.11 CONCEPTUAL SITE MODEL

A typical goal of the DQO process is to develop sampling designs that confirm or reject the conceptual site model so the model can be revised when additional data become available. Table A1-13 presents a tabular depiction of the 300-FF-5 OU conceptual site model components.

Table A1-13. Tabular Depiction of the Conceptual Site Model. (2 Pages)

Media	COCs	Source	Release Mechanism	Migration Pathways	Potential Receptors
Groundwater	All	Construction or demolition debris and liquid waste disposal/spills	Leachate infiltration	Contaminated waste/soil leachate to groundwater	Samplers, future industrial workers

Table A1-13. Tabular Depiction of the Conceptual Site Model. (2 Pages)

Media	COCs	Source	Release Mechanism	Migration Pathways	Potential Receptors
Exposure Scenario: Sampler or future worker exposure to contaminated groundwater.					
Surface water and seep water	All	Same as groundwater	Contaminated groundwater flow to river	Contaminated groundwater transport to shoreline seeps and Columbia River	Site workers, shoreline recreational users, and aquatic/riparian plants and animals
Exposure Scenario: Site worker, recreational user, or aquatic/riparian biota (i.e., plant and animal) exposure to contaminated seep water during low river flow.					

A1.12 STATEMENT OF THE PROBLEM

Over the past 5 years, the scope of the 300-FF-5 O&M plan has changed for the following reasons:

- Expansion of the OU boundary
- The identification of new 300 Area groundwater contamination
- Heightened concern about contaminated groundwater entering the Columbia River in the 300 Area
- Evaluation needs regarding the effectiveness of MNA as the selected remedial alternative for the 300-FF-5 OU.

This DQO effort addresses the data needed to address these four items of concern and identifies groundwater monitoring and evaluation approaches for consideration during the revision of the *Operation and Maintenance Plan for the 300-FF-5 Operable Unit* (DOE-RL 1996).

A2.0 STEP 2 – IDENTIFY THE DECISION

The purpose of DQO Step 2 is to define the principal study questions (PSQs) that need to be resolved to address the problem identified in DQO Step 1, and the AAs that would result from the resolution of the PSQs. The PSQs and AAs are then combined into decision statements (DSs) that express a choice among AAs. Table A2-1 presents the task-specific PSQs, AAs, and resulting DSs. This table also provides a qualitative assessment of the severity of the consequences of taking an AA if it is incorrect. This assessment takes into consideration human health and environment (flora/fauna), as well as political, economic, and legal ramifications.

Table A2-1. Summary of Step 2 Information. (3 Pages)

PSQ-AA #	Alternative Action	Description of Consequences of Implementing the Wrong Alternative Action	Severity of Consequences (Low/Moderate/Severe)
PSQ #1 – What COCs are associated with the 300-FF-5 groundwater plumes?			
1a	COCs are known; no more sampling/analysis needed.	Miss COCs that are important risk or remedial action considerations.	Low (Ongoing 300 Area groundwater monitoring has assessed presence/absence of all COPCs.)
1b	COCs are not known; more sampling/analysis is needed.	Conduct sampling/analysis that is not needed; no more COCs identified.	Low (Schedule and cost related.)
DS #1 – The 300-FF-5 plume COCs are (or are not) identified.			
PSQ #2 – What is the extent of contamination exceeding drinking water MCLs for the 300-FF-5 groundwater plumes?			
2a	The MCL contours for each area of concern COC can be mapped.	Areas of groundwater contamination in excess of the MCL would not be known; remedial actions to address the plume may be insufficient.	Low (Human health protectiveness not a major issue since local groundwater is not a drinking water source; effectiveness of natural attenuation as a remedial action is under investigation over next 5-year CERCLA review period.)
2b	The MCL contours for each area of concern COC cannot be mapped.	Unnecessary investigations would be conducted to define the MCL contours; remedial actions to address the plume may be excessive.	Moderate (Schedule and cost related.)
DS #2 – The extent of contamination exceeding drinking water MCLs is (or is not) known for the 300-FF-5 groundwater plumes.			

Table A2-1. Summary of Step 2 Information. (3 Pages)

PSQ-AA #	Alternative Action	Description of Consequences of Implementing the Wrong Alternative Action	Severity of Consequences (Low/Moderate/Severe)
PSQ #3 – Will MNA result in groundwater compliance with MCLs or AWQC at potential human or ecological exposure locations (i.e., local groundwater, shoreline seep water, and Columbia River water near the seeps)?			
3a	MNA will result in MCL and/or AWQC compliance; no further remedial actions are required for human health or environmental protection.	MNA is not an effective remedial action; human health and/or environmental risks may exist but are not recognized; additional remedial actions are needed but would not be considered or implemented.	Low (Human health protectiveness is not major issue since groundwater is not a drinking water source; effectiveness of MNA as a remedial action is under investigation over the next 5-year CERCLA review period.) Moderate (direct seep exposure is limited to low-flow river stage periods)
3b	MNA will not result in MCL/AWQC compliance; additional remedial actions are required for human health or environmental protection.	MNA is not recognized as an effective remedial action; human health and/or environmental risks may be perceived but do not exist; additional remedial actions are implemented but are not needed.	Low (Effectiveness of MNA as a remedial action is under investigation over next 5-year CERCLA review period; additional remedial measures would not be considered until 2006.)
DS #3 – MNA will (or will not) result in groundwater compliance with MCLs or AWQC at potential human or ecological exposure locations.			
PSQ #4 – Are resident aquatic biota (i.e., plants/animals living in the seeps or Columbia River adjacent to seeps) or resident terrestrial biota (i.e., plants/animals living adjacent to the seeps) adversely affected by 300-FF-5 groundwater contamination?			
4a	Resident biota are not adversely affected by groundwater contamination; no additional groundwater remedial actions are needed.	Resident biota continue to be adversely affected by groundwater contaminants but appropriate additional remedial actions are not considered or implemented.	Moderate (Direct seep exposure is limited to low-flow river stage periods.)

Table A2-1. Summary of Step 2 Information. (3 Pages)

PSQ-AA #	Alternative Action	Description of Consequences of Implementing the Wrong Alternative Action	Severity of Consequences (Low/Moderate/Severe)
4b	Resident biota are adversely affected by groundwater contamination; additional groundwater remedial actions are needed.	Resident biota are not adversely affected by groundwater contaminants but additional remedial actions are implemented.	Low (Effectiveness of MNA as a remedial action is under investigation over next 5-year CERCLA review period; additional remedial measures would not be considered until 2006.)
DS #4 – Resident aquatic and terrestrial biota are (or are not) adversely affected by 300-FF-5 groundwater contamination.			

A3.0 STEP 3 – IDENTIFY INPUTS TO THE DECISION

The purpose of DQO Step 3 is to identify the types of data needed to resolve each of the DSs. The data may already exist or may be derived from computational or sampling and analysis methods. Analytical performance requirements (e.g., practical quantitation limit [PQL], precision, and accuracy) are provided for any new data to be collected.

A3.1 INFORMATION REQUIRED TO RESOLVE DECISION STATEMENTS

Table A3-1 specifies the information (data) required to resolve the DSs identified in Table A2-1 and indicates whether the data already exist. For existing data, the source references are provided with a qualitative assessment regarding the sufficiency of the data to resolve the DSs. The qualitative assessment is based on an evaluation of quality control data (e.g., spikes, duplicates, and blanks), detection limits, methods, etc.

Table A3-1. Required Information and Reference Sources. (2 Pages)

DS #	Remediation Variable	Required Data	Does Data Exist? (Y/N)	Source Reference	Sufficient Quality (Y/N)	Additional Information Required? (Y/N)
1	Drinking water MCLs (in groundwater)	Groundwater COC concentrations	Y	PNNL annual reports (PNNL 1997, 1998, 1999, 2000)	N	Y
		Waste site COCs that could contaminate groundwater	Y	300-FF-1 and 300-FF-2 feasibility study reports (DOE-RL 1993, 2000)	N	Y
2 and 3	Drinking water MCLs (in groundwater and seeps)	COC concentrations in wells down- and cross-gradient from plume sources and in seeps	Y	PNNL annual reports (PNNL 1997, 1998, 1999, 2000)	N	Y
	AWQC (in seeps and Columbia River near seeps)	Seep/river COC concentrations	Y	PNNL annual reports (PNNL 1997, 1998, 1999, 2000)	N	Y

Table A3-1. Required Information and Reference Sources. (2 Pages)

DS #	Remediation Variable	Required Data	Does Data Exist? (Y/N)	Source Reference	Sufficient Quality (Y/N)	Additional Information Required? (Y/N)
4	AWQC (seeps and Columbia River near seeps) for resident aquatic biota	Seep/river COC concentrations	Y	PNNL annual reports (PNNL 1997, 1998, 1999, 2000)	N	Y
	Resident aquatic and terrestrial plant/animal tissue concentrations greater than "control" levels	Seep, near-seep, and "control" aquatic/ terrestrial plant and animal tissue concentrations	N	PNNL annual reports (PNNL 1997, 1998, 1999, 2000)	N	Y

A3.2 BASIS FOR SETTING THE ACTION LEVEL

An "action level" is a threshold value that provides the criterion for choosing between AAs. Table A3-2 identifies the basis (i.e., regulatory or risk-based) for establishing action levels for the COCs. The numerical values for the action levels are defined in Step 5.

Table A3-2. Basis for Setting Action Level.

DS #	Remediation Variable	COCs	Basis for Setting Action Level
1	Drinking water MCLs (in groundwater)	All	Federal/state ARARs
2 and 3	Drinking water MCLs (in seeps and groundwater) AWQC (seeps and river)		Federal/state ARARs
4	AWQC (seeps and river) for resident aquatic biota Plant/animal tissue concentrations greater than "control" levels		Federal/state ARARs "Significant" seep/river-affected tissue concentration differences from control areas

A3.3 COMPUTATIONAL AND SURVEY/ANALYTICAL METHODS

Table A3-3 documents where data do not exist or are of insufficient quality to resolve the DSs. Table A3-3 also presents computational, survey, and sampling methods that could be used to obtain the required data.

Table A3-3. Information Required to Resolve the Decision Statements.

DS #	Remediation Variable	Required Data	Computational Methods	Survey/Analytical Methods
1	Drinking water MCLs (groundwater)	None – COCs are adequately defined.	N/A	N/A
2 and 3	Drinking water MCLs (in seeps and groundwater) AWQC (seeps and river)	COC concentrations in groundwater, seeps, and Columbia River		Standard water methods (laboratory)
4	AWQC (seeps and river) for resident aquatic biota Plant/animal tissue concentrations greater than "control" levels	COC concentrations in seeps and Columbia River Biota tissue (aquatic and terrestrial) from seep-affected and control areas		Standard water and tissue methods (laboratory)

N/A = not applicable

Table A3-4 presents details on the computational methods identified in Table A3-3.

Table A3-4. Details on Identified Computational Methods.

DS #	Computational Method	Source/Author	Application to Study
1, 2, 3, and 4	None identified	Not applicable	

Table A3-5 identifies the survey and/or analytical methods that would provide the required information to resolve the DSs. The limitations associated with each method and the estimated cost are also provided.

Table A3-5. Potentially Appropriate Survey/Analytical Methods. (2 Pages)

DS #	Remediation Variable	Potentially Appropriate Survey/ Analytical Method	Possible Limitations	Cost
2 and 3	Drinking water MCLs (in seeps and groundwater)	Standard water methods (laboratory)	None identified for groundwater.	Low
	AWQC (seeps and river)		Representative sample collection (if seeps/river shallow or access is difficult).	

Table A3-5. Potentially Appropriate Survey/Analytical Methods. (2 Pages)

DS #	Remediation Variable	Potentially Appropriate Survey/ Analytical Method	Possible Limitations	Cost
4	AWQC (seeps and river) for resident aquatic biota		Representative sample collection (if seeps/river shallow or access is difficult).	
	Plant/animal tissue concentrations greater than "control" levels		Matrix (media) problems with tissues.	

A3.4 ANALYTICAL PERFORMANCE REQUIREMENTS

Table A3-6 defines the analytical performance requirements for the required data.

Table A3-6. Analytical Performance Requirements. (2 Pages)

DS #	COCs	Survey/ Analytical Method	Preliminary Action Level	PQL	Precision Req't	Accuracy Req't
2, 3, and 4	Trichloroethylene	SW-846 Method 8260 (groundwater low-level detection limit)	3.98 µg/L	1 µg/L	[a]	[a]
	1,2-Dichloroethylene	SW-846 Method 8260	70 µg/L	5 µg/L	[a]	[a]
	1,1-Dichloroethylene	SW-846 Method 8260	7 µg/L	5 µg/L	[a]	[a]
	Vinyl chloride	SW-846 Method 8260	2 µg/L	10 µg/L	[a]	[a]
	Nitrate[d]	SW-846 9056 Anions	10 mg/L	250 µg/L	[a]	[a]
	Tetrachloroethylene	SW-846 Method 8260 (groundwater low-level detection limit)	0.858 µg/L	1 µg/L	[a]	[a]
	Uranium (total)	Laboratory-specific	30 µg/L[b]	1 pCi/L	±20%	75% to 130%
	Tritium (H-3)	Laboratory-specific	20,000 pCi/L	400 pCi/L	±20%	75% to 130%

Table A3-6. Analytical Performance Requirements. (2 Pages)

DS #	COCs	Survey/ Analytical Method	Preliminary Action Level	PQL	Precision Req't	Accuracy Req't
	Strontium-90	Laboratory-specific	8 pCi/L	2 pCi/L	±20%	75% to 130%
	Tributyl phosphate[d]	SW-846, Method 8270	None[c]	100 μg/L	[a]	[a]

[a] As defined by the referenced SW-846 method.
[b] Total uranium value.
[c] Only an occupational health and safety breathing hazard was found.
[d] These contaminants are not COCs, but are of interest as potential 300 Area plume tracers.

A4.0 STEP 4 – DEFINE THE BOUNDARIES OF THE STUDY

The objective of DQO Step 4 is to identify areas of interest, define spatial and temporal boundaries that apply to the DSs, define the "scale" of the decisions, and document constraints that must be considered in the sampling design. This step helps to ensure that the sampling design will result in data that accurately reflect the true condition of the groundwater plumes, shoreline seeps, Columbia River, and resident plants/animals under investigation.

A4.1 AREAS OF INTEREST

Prior to defining the spatial and temporal boundaries of the groundwater plumes and seeps under investigation, it is necessary to clearly define the "areas of interest" that apply to each DS. The intent of Table A4-1 is to document the attributes of each area of interest to help ensure the focus of the study is not ambiguous.

Table A4-1. Characteristics that Define the Areas of Interest.

<table>
<tr><th>DS #</th><th>Areas of Interest</th><th>Unit Measurement Size</th><th>Total Number of Potential Measurement Units Within the Population</th></tr>
<tr><td rowspan="5">2 and 3</td><td>618-11 Burial Ground plume</td><td rowspan="5">Approximately 2 L of water per groundwater well, Columbia River sample site, or seep</td><td rowspan="6">Infinite</td></tr>
<tr><td>618-10 Burial Ground and 316-4 Crib plume</td></tr>
<tr><td>Plume in the vicinity of well 399-3-10</td></tr>
<tr><td>300-FF-1 and 300-FF-2 OU plume</td></tr>
<tr><td>Columbia River and seeps adjacent to the 300-FF-2 OU</td></tr>
<tr><td rowspan="2">4</td><td rowspan="2">Columbia River and seeps adjacent to the 300-FF-1 and 300-FF-2 OUs</td><td>Approximately 2 L of water per seep or Columbia River sample site</td></tr>
<tr><td>Approximately 10 g of tissue per aquatic or terrestrial specie associated with each seep and "control" area</td><td>N/A</td></tr>
</table>

N/A = not applicable

A4.2 GEOGRAPHIC BOUNDARIES

Table A4-2 identifies the geographic boundaries that apply to the DSs. Limiting the geographic boundaries of the study area helps to ensure that the investigation does not expand beyond the original scope.

Table A4-2. Geographic Boundaries of the Investigation.

DS #	Geographic Boundaries of the Investigation
2 and 3	The area down- and cross-gradient from the 618-11 Burial Ground tritium plume.
	The area down- and cross-gradient from the 618-10 Burial Ground and 316-4 Crib uranium/tributyl phosphate plume.
	The area down- and cross-gradient from well 399-3-10.
	The area down- and cross-gradient from the 300-FF-1/2 OU uranium plume.
	The seeps (multiple locations) entering the Columbia River along the 300-FF-1/2 OU.
	The Columbia River adjacent to the seeps (multiple locations) along the 300-FF-1/2 OU.
4	The seep "footprints" (multiple locations) along the Columbia River adjacent to the 300-FF-1/2 OU.
	The Columbia River adjacent to the seeps (multiple locations) along the 300-FF-1/2 OU.
	"Control" areas associated with the seep and Columbia River sample sites.

A4.3 ZONES WITH HOMOGENEOUS CHARACTERISTICS

Table A4-3 defines the 300-FF-5 areas of concern with relatively homogeneous characteristics.

Table A4-3. Zones with Homogeneous Characteristics. (2 Pages)

DS #	Population of Interest	Zone	Homogeneous Characteristic Logic
2 and 3	618-11 Burial Ground tritium plume	Groundwater	618-11 Burial Ground is COC source
	618-10 Burial Ground and 316-4 Crib uranium/tributyl phosphate plume	Groundwater	618-10 Burial Ground and 316-4 Crib are COC sources
	Plume in the vicinity of well 399-3-10		This is a plume in the vicinity of well 399-3-10
	300-FF-1/2 OU uranium plume		Plume caused by same sources
	Seeps (multiple locations) entering the Columbia River adjacent to the 300-FF-1/2 OU	Seep water	Each seep is affected by upgradient (300-FF-1/2) contaminated areas
	Columbia River adjacent to the seeps (multiple locations)	River water	Each seep is affected by upgradient (300-FF-1/2) contaminated areas

Table A4-3. Zones with Homogeneous Characteristics. (2 Pages)

DS #	Population of Interest	Zone	Homogeneous Characteristic Logic
4	Seeps (multiple locations) entering the Columbia River adjacent to the 300-FF-1/2 OU	Seep water	Each seep is affected by upgradient (300-FF-1/2) contaminated areas
	Aquatic and terrestrial biota associated with the seeps entering the Columbia River adjacent to the 300-FF-1/2 OU	Individual species tissues	Biota affected by the 300-FF-2 COCs associated with each seep.
	Aquatic and terrestrial biota associated with the Columbia River adjacent to the seeps (multiple locations)		Biota affected by the 300-FF-2 COCs associated with each seep.
	Aquatic and terrestrial biota from "control" areas (i.e., not associated with the seeps or the Columbia River near the seeps)		Biota not affected by the 300-FF-2 COCs associated with each seep.

A4.4 TEMPORAL BOUNDARIES

Table A4-4 documents temporal boundaries (timeframe over which DSs apply) for the DSs. Temporal boundaries refer to the duration of the decisions (e.g., number of years) and when data should optimally be collected (e.g., season or time of day).

Table A4-4. Temporal Boundaries of the Investigation.

DS #	Timeframe	When to Collect Data
2 and 3	2001 through 2006 (next 5-year monitoring period)	High- and low-river-flow periods (both periods for groundwater, only low-flow period for seeps and river water)
4	2001 through 2006 (next 5-year monitoring period)	Low-river-flow periods (annually when seeps are exposed)

A4.5 SCALE OF DECISION MAKING

In Table A4-5, the scale of decision making has been defined for each DS. The scale of decision making is defined by joining the population of interest and the geographic and temporal boundaries of the area under investigation.

Table A4-5. Scale of Decision Making. (2 Pages)

DS #	Populations of Interest	Geographic Boundary	Temporal Boundary		Scale of Decision
			Timeframe	When to Collect Data	
2 and 3	618-11 Burial Ground tritium plume	The area down- and cross-gradient from the 618-11 tritium plume.	2001 through 2006 (next 5-year monitoring period)	High- and low-river-flow periods (semi-annually) for groundwater. Low-river-flow periods only (annually) for seep and river water.	Locations down- and cross-gradient from the plume areas of concern (including affected seeps and Columbia River sites), for the next 5-year monitoring period, during high- and low-river-flow periods (semi-annually for groundwater, annually for seep and river water).
	618-10 Burial Ground and 316-4 Crib uranium/ tributyl phosphate plume	The area down- and cross-gradient from the 618-10 Burial Ground/316-4 Crib uranium/tributyl phosphate plume.			
	Trichloroethylene/ tetrachloroethylene in the vicinity of well 399-3-10	The area down- and cross-gradient from well 399-3-10.			
	300-FF-2 OU uranium plume	The area down- and cross-gradient from the 300-FF-2 the uranium plume OU.			
	Seeps (multiple locations) entering the Columbia River adjacent to the 300-FF-2 OU	The seep "footprints" entering the Columbia River adjacent to the 300-FF-2 OU.			
	The Columbia River adjacent to the seeps (multiple locations)	The Columbia River adjacent to the seeps along 300-FF-2 OU.			
4	Seeps (two locations) entering the Columbia River adjacent to the 300-FF-2 OU	The seep "footprints" entering the Columbia River adjacent to the 300-FF-2 OU.	2001 through 2006 (next 5-year monitoring period)	Low-river-flow periods (seeps exposed)	The seep "footprints," Columbia River areas influenced by the seeps, and control areas not associated with the seeps, for the next 5-year monitoring period, during low-river-flow periods (annually).

Table A4-5. Scale of Decision Making. (2 Pages)

DS #	Populations of Interest	Geographic Boundary	Temporal Boundary		Scale of Decision
			Timeframe	When to Collect Data	
	Aquatic and terrestrial biota associated with the seeps (multiple locations) entering the Columbia River adjacent to the 300-FF-2 OU	The Columbia River areas influenced by the seeps.			
	Aquatic and terrestrial biota associated with the Columbia River adjacent to the seeps (multiple locations)	"Control" areas not associated with the seeps.			
	Aquatic and terrestrial biota from "control" areas (i.e., not associated with the seeps)				

A4.6 PRACTICAL CONSTRAINTS

Table A4-6 identifies all of the practical constraints that may impact the data collection effort. These constraints include physical barriers, difficult sample matrices, high radiation areas, or any other condition that will need to be taken into consideration in the design and scheduling of the sampling program.

Table A4-6. Practical Constraints on Data Collection.

1. Can only access seeps during low Columbia River flow periods (primarily early summer through late fall).
2. Columbia River flows can have a significant effect on 300-FF-5 groundwater quality. Periods of pure (i.e., undiluted) groundwater presence are limited to low Columbia River flow periods (primarily early summer through late fall).
3. Access restrictions due to waste sites, buildings, and active facilities could influence the placement of new monitoring wells.
4. Limited resident biota (aquatic or terrestrial) closely associated with seeps. Variable exposure duration due to seep water not influenced (diluted) by river water.

A5.0 STEP 5 – DEVELOP A DECISION RULE

The purpose of DQO Step 5 is initially to define statistical parameters of interest (e.g., mean or 95% upper confidence level [UCL]) that could be compared against the action levels. The statistical parameter of interest specifies the characteristic or attribute that the decision makers would like to know about the groundwater, seep water, Columbia River water, or seep-influenced biota. Decision rules (DRs) are developed for the DSs in the form of "IF…THEN…" statements that incorporate the parameters of interest, the scale of the decision, the action levels, and the AAs that would result from resolving the DSs.

A5.1 INPUTS NEEDED TO DEVELOP DECISION RULES

Tables A5-1 and A5-2 present the information needed to formulate the DRs. This information includes the DSs and AAs identified earlier (in DQO Step 2), the scale of the decision (from DQO Step 4), the statistical parameters of interest, and the action levels for the COCs.

Table A5-1. Decision Statements.

DS #	Decision Statement
1	The 300-FF-5 plume COCs are (or are not) identified.
2	The extent of contamination exceeding drinking water MCLs is (or is not) known for the 300-FF-5 groundwater plumes.
3	Natural attenuation will (or will not) result in groundwater compliance with MCLs or AWQC at potential human or ecological exposure locations.
4	Resident aquatic and terrestrial biota are (or are not) adversely affected by 300-FF-5 groundwater contamination.

Table A5-2. Inputs Needed to Develop Decision Rules.

DS #	COCs	Statistical Parameters of Interest	Scale of Decision Making	Final Action Level	Alternative Actions
1	N/A (existing data have resolved DS #1)	N/A	N/A	N/A	N/A
2	Trichloroethylene, total 1,2-dichloro-ethylene, 1,1-dichloroethylene, vinyl chloride, tetra-chloroethylene, total uranium, tritium, and strontium-90	Maximum	The areas down- and cross-gradient from the plume areas of concern, for the next 5-year monitoring period, during high- and low-river flow periods (both periods for groundwater, low-flow periods only for seeps/river water).	MCL	The MCL contour for each area of concern COC can be (or cannot be) mapped.
3	Trichloroethylene, total 1,2-dichloro-ethylene, 1,1-dichloroethylene, vinyl chloride, tetra-chloroethylene, total uranium, tritium, and strontium-90		The areas down- and cross-gradient from the plume areas of concern, for the next 5-year monitoring period, during high- and low-river flow periods (both periods for groundwater, low-flow periods only for seeps/sediments/river water).	MCL, MTCA soil criteria[a] and AWQC	Natural attenuation is (or is not) resulting in MCL/AWQC/MTCA compliance; no further (or additional) remedial actions are required for human health or environmental protection.
4	Total uranium and strontium-90		Residential biota influenced by the seeps, for the next 5-year monitoring period, during low-river flow periods.	AWQC and/or tissue concentra-tions greater than background tissue levels	Resident biota are not (or are) adversely affected by groundwater contamination. No additional groundwater remedial actions are needed.

[a] MTCA soil criteria are suggested as action levels for seep-related sediments.
N/A = not applicable

A5.2 DECISION RULES

Table A5-3 presents DRs that correspond to each of the DSs identified in Table A5-1.

Table A5-3. Decision Rules.

DS #	Media	Decision Rules
2	Ground-water	If existing information (i.e., existing monitoring well and seep data) can be used to define the groundwater MCL contours for the COC plumes under consideration, then the extent of the plumes has been defined and the existing monitoring well network can be used to monitor the plumes. If existing information (i.e., existing monitoring well and seep data) cannot be used to define the groundwater MCL contours for the COC plumes under consideration, then the extent of the plumes has not been defined and the existing monitoring well network must be expanded (i.e., additional monitoring wells installed).
3	Ground-water	If plume-specific maximum groundwater COC concentrations indicate that MCL compliance is being achieved or will be achieved by 2018 (i.e., COC concentrations < MCLs, holding steady, or down-trending), then MNA will result in MCL compliance and no additional remedial actions are required. If plume-specific maximum groundwater COC concentrations indicate that MCL compliance will not be achieved by 2018 (i.e., COC concentrations > MCLs or up trending), then MNA will not result in MCL compliance and additional remedial action would be evaluated.
3 and 4	Seep and river water	If plume-specific maximum seep and/or river water COC concentrations indicate that AWQC compliance is being achieved or will be achieved by 2018 (i.e., COC concentrations < AWQC, holding steady, or down-trending), then MNA will result in AWQC compliance and no additional remedial actions would be required. If plume-specific maximum seep and/or river water COC concentrations indicate that AWQC compliance will not be achieved by 2018 (i.e., COC concentrations > AWQC or up-trending), then MNA will not result in AWQC compliance and additional remedial action would be evaluated.
4	Biota tissue	If seep-affected maximum COC concentrations in biota tissue (aquatic or terrestrial) do not substantially exceed "control" biota tissue levels, then it would be assumed that the biota are not being adversely affected and no additional remedial actions would be required for the seep, the groundwater affecting the seep, or groundwater COC source(s). If seep-affected maximum COC concentrations in biota tissue (aquatic or terrestrial) substantially exceed "control" biota tissue levels, then it would be assumed that the biota are being adversely affected and additional remedial actions would be evaluated for the seep, the groundwater affecting the seep, and the groundwater COC source(s).

A6.0 STEP 6 – SPECIFY TOLERABLE LIMITS ON DECISION ERRORS

Because analytical data can only estimate the true condition of the site under investigation, decisions based on measurement data could be in error (i.e., decision error). For this reason, the primary objective of DQO Step 6 is to determine which DSs require statistically based sample designs. For DSs requiring statistically based sample designs, DQO Step 6 defines tolerable limits on the probability of making decision errors.

A6.1 STATISTICAL VERSUS NON-STATISTICAL SAMPLING DESIGN

Table A6-1 provides a summary of the information used to select statistical or non-statistical sampling designs for the DSs. The factors considered in making this selection include the timeframe over which the DSs apply, the qualitative consequences of an inadequate sampling design, and the accessibility of the site if resampling is required.

Table A6-1. Statistical Versus Non-Statistical Sampling Design.

DS #	Time-frame (Years)	Qualitative Consequences of Inadequate Sampling Design (Low/Moderate/Severe)	Resampling Access After Remediation (Accessible/Inaccessible)	Proposed Sampling Design (Statistical/ Non-Statistical)
2	5	Low to moderate	Accessible	Non-statistical; existing plume information supports sampling location selection, statistical sampling not required to support plume extent decisions.
3				Non-statistical; statistical sampling not required to support plume MNA or seep/river contamination conclusions.
4				Non-statistical; statistical sampling not required to support seep/river water quality influence on biota decisions.

A6.2 NON-STATISTICAL DESIGNS

For the DSs to be resolved using a non-statistical design, there is no need to complete the remainder of DQO Step 6. Because a non-statistical design is used, the remainder of Section 6.0 is not applicable (proceed to Section 7.1 for details on the selected non-statistical sampling designs).

A6.3 STATISTICAL DESIGNS

An initial step in the process of establishing a statistically based sample design to define the expected range of the statistical parameter of interest (i.e., mean or 95% UCL) for each COC. Table A6-2 defines the expected statistical parameter of interest concentration ranges for each COC based on the evaluation of historical analytical data. This table is not applicable.

Table A6-2. Statistical Parameter of Interest Concentration Ranges.

DS #	Media	COCs	Statistical Parameter of Interest	Range	
				Lower Limit	Upper Limit
Not applicable					

A6.4 DECISION ERRORS

The two types of decision error are as follows: treating (i.e., managing and disposing) clean site media as if it were contaminated, and treating (i.e., managing and disposing) contaminated site media as if it were clean. The decision error that has the more severe consequence is the latter since the error could result in human health and/or ecological impacts.

A6.5 NULL HYPOTHESIS

Table A6-3 identifies the null hypothesis that applies to the site under investigation. The term "null hypothesis" refers to the baseline condition of the site, which has been defined based on the historical data and process knowledge identified in the scoping summary report. The null hypothesis states the opposite of what is hoped to be demonstrated. Table A6-3 is not applicable.

Table A6-3. Defining the Null Hypothesis.

Null Hypothesis Statement	Indicate Selection
Site media is assumed to be contaminated until it is shown to be clean (i.e., waste stream does not meet disposal criteria).	N/A
Site media is assumed to be clean until it is shown to be contaminated (i.e., waste stream does meet disposal criteria).	

N/A = not applicable

A6.6 TOLERABLE LIMITS FOR DECISION ERROR

For each DS, Tables A6-4 and A6-5 present the selected statistical design to be implemented (i.e., simple random or random systematic), the boundaries of the gray region, and the probability values to points above and below the gray region that reflect the decision maker's tolerable limits for making an incorrect decision. The following tables are not applicable.

Table A6-4. Statistical Designs.

DS #	Media	Selected Statistical Design	Boundaries of the Gray Region	Tolerable Limits for Incorrect Decision	
				At LBGR	At Action Level
Not applicable					

LBGR = lower bound of gray region

Table A6-5. Tolerable Decision Errors.

DS #	Media	COCs	Statistical Parameter of Interest	Statistical Parameter of Interest Range	Final Action Level	Gray Region	Tolerable Decision Error	
							LBGR (%)	At Action Level (%)
Not applicable								

A7.0 STEP 7 – OPTIMIZE THE DESIGN

The objective of DQO Step 7 is to present data collection design options that meet the data quality requirements specified in DQO Steps 1 through 6. The most resource-effective design that satisfies the data quality requirements can then be selected from the options evaluated. Table A6-3 documented DSs requiring statistical or non-statistical sampling designs.

A7.1 NON-STATISTICAL DESIGN

Tables A7-1 to A7-3 are completed for the DSs where a non-statistical sampling approach is appropriate.

A7.1.1 Non-Statistical Screening Method Alternatives

Table A7-1 identifies all of the screening technologies that were considered to resolve each DS and the optional methods of implementing each technology. The table also summarizes the limitations associated with each screening technology and/or method of implementation and provides an estimated cost for implementation.

Table A7-1. Potential Non-Statistical Screening Alternatives.

DS #	Media	Screening Technology	Potential Implementation Designs	Limitations	Cost
2, 3, and 4	All	Not applicable			

A7.1.2 Non-Statistical Sampling Method Alternatives

Table A7-2 identifies the media to be sampled and alternative methods for collecting the samples. This table also identifies limitations associated with each sampling method and/or design. An estimated cost for each sampling design is provided for comparison purposes.

Table A7-2. Potential Non-Statistical Sampling Method Alternatives. (3 Pages)

DS #	Media	Sampling Method	Potential Implementation Designs	Limitations	Cost
2 and 3	Groundwater	Monitoring well sampling	Sample groundwater wells (existing or new) associated with the plume areas of interest. Use monitoring data to assess contaminant concentration trends and plume status over time. Use monitoring data as input to model COC concentrations and plume status over time. Monitoring strategies for the 618-11 and 618-10 Burial Grounds and 316-4 Crib plumes would be similar (plumes are discrete and unaffected by river stage variations). Monitoring locations should be determined relative to local groundwater flow direction and plume sources (typical upgradient/downgradient characterization approach). Combination of new and existing wells should satisfy monitoring needs. The monitoring strategy for the 300-FF-1/2 OU and plumes in the vicinity of well 399-3-10 would be similar (plumes are affected by river stage variations). Select monitoring locations based on groundwater flow direction, plume sources, and river influence zones).	Access to install new wells or sample existing wells in 618-11 Burial Ground area of concern will require ENW approval. Monitoring and data evaluation results may be inconclusive regarding plume status and/or MCL compliance (particularly for the plumes affected by river stage variations).	

Table A7-2. Potential Non-Statistical Sampling Method Alternatives. (3 Pages)

DS #	Media	Sampling Method	Potential Implementation Designs	Limitations	Cost
			Geographical aerial coverage strategy (i.e., coverage of 300-FF-2 OU area) most suitable. Combination of new and existing wells should satisfy monitoring needs.		
3 and 4	Surface water (seeps and river water)	Grab samples	Collect seep water near shoreline "source" (i.e., where the seep exits the riverbank). Analyze seep samples for COCs plus hardness (to assess river water proportion of seep water).	Seep access for grab sample collection limited to low Columbia River flow periods. Seasonal seep quality (i.e., river water bank storage influence during early part of low-flow periods; less influence during later part of low-flow periods).	
		"Aqua tube" grab samples	Collect Columbia River water along micro-transects in areas affected by seeps.	Aqua tube samples may not accurately represent seep quality (i.e., quality changes when groundwater is exposed to the atmosphere as it exits the riverbank; river water bank storage influence during early part of low-flow periods; less influence during later part of low-flow periods).	
		Seep or aqua tube composite samples	Collect groundwater "feeding" the seeps just upgradient from seep source along river shoreline. Analyze for COCs plus specific conductivity (to assess river water proportion of seep water).	Malfunction of composite sampling device; tampering by river recreational users; holding time limits for water samples; issues with ongoing preservation of composite water samples in field.	

Table A7-2. Potential Non-Statistical Sampling Method Alternatives. (3 Pages)

DS #	Media	Sampling Method	Potential Implementation Designs	Limitations	Cost
			Use automatic samplers to collect seep water over time (e.g., 500 mL/day over a 4-week period) to "average" river water bank storage influences. Analyze for COCs plus hardness (to assess river water proportion of seep water).		
4	Biota tissue	Collect "experimental" plants/animals (aquatic and terrestrial) potentially affected by seep water and "control" plants/animals from same general area not affected by seep water.	Collect experimental and control area plants; analyze whole plants or portions (e.g., roots, leaves, and stems) expected to bio-accumulate seep COCs.	More than one plant or animal of a given species may be required to develop a sample (depends on weight of tissue sample required).	
			Sampling could involve several individual plants from within the seep influence and control areas OR composite samples made-up from several plants throughout the seep influence and control areas.	Seasonal variance in tissue results (i.e., spring/ summer/fall differences due to growth rates and exposure durations).	
			Collect experimental and control area animals; analyze whole animals or portions (e.g., bone, muscle, and organs) expected to bio-accumulate seep COCs.	Uncertainty regarding resident animal exposure pathways and durations to the seeps.	
			Sampling could involve several individual animals from within the seep influence and control areas OR composite samples made-up from several animals throughout the seep influence and control areas.	Matrix affects in analyzing plant/animal tissues could influence ability to achieve acceptable detection limits.	

A7.1.3 Non-Statistical Implementation Design

Table A7-3 presents the selected screening technologies and sampling methods for resolving each DS, along with a summary of the proposed implementation design. The table also provides the basis for the selected implementation design.

Table A7-3. Selected Implementation Design. (2 Pages)

DS #	Media	Selected Screening Technology(s)	Selected Sampling Method(s)	Potential Implementation Designs
2 and 3	Groundwater	None	Groundwater monitoring	Monitor existing/new wells quarterly.
				Monitor existing/new wells semi-annually (at high- and low-river stages).
				Monitor existing/new wells annually (at high- or low-river stage).
Selected Implementation Design: Monitor existing/new wells on a semi-annual basis.				
Basis for Selection: Semi-annual monitoring would provide sufficient data to evaluate plume status, COC trends, and the effectiveness of MNA either through trend analysis or modeling. Quarterly monitoring is excessive and interpreting the results could be confounded by Columbia River stage variations. Annual monitoring would not result in sufficient data for the evaluations needed and would not allow an evaluation of COC mobilization by river stage variations.				
3 and 4	Seep and river water	None	Grab sampling (seep and river water)	Periodic (e.g., monthly or annual) grab samples from seeps and adjacent river areas during low-flow periods.
			Composite sampling (seep and river water)	Periodic (e.g., monthly or annual) composite samples of from seeps and adjacent river areas during low-flow periods.
Selected Implementation Design: Annual grab samples from seeps and adjacent river areas during low-flow periods. Analyze for COCs and hardness (to assess river water proportion of seep flow).				
Basis for Selection: Annual grab samples from individual seeps and their adjacent river areas during low-river stage would provide an assessment of seep/river water quality and an evaluation of MCL/AWQC compliance under worst-case conditions. Grab sampling avoids the concerns associated with composite sampling (e.g., tampering, sample preservation or changes in bank storage influence).				

Table A7-3. Selected Implementation Design. (2 Pages)

DS #	Media	Selected Screening Technology(s)	Selected Sampling Method(s)	Potential Implementation Designs
4	Biota tissue	None	Whole organisms	Collect/analyze whole plants/animals from seep-influenced areas and control areas.
			Partial organisms (e.g., organs, bone, leaves, roots)	Collect/analyze selected plant/animal parts from seep-influenced areas and control areas.
			Whole and partial organisms	Collect/analyze whole plants/animals and select plant/animal parts from seep-influenced areas and control areas.
Selected Implementation Design: Collect/analyze whole plants/animals and select plant/animal parts from seep-influenced areas and control areas. Whole plant/animal samples are anticipated for aquatic biota because the expected plants (algae) and animals (freshwater clams) living in the seeps and affected river areas are eaten whole by grazers/predators and cannot be easily dissected into significant parts. Whole and partial terrestrial plant samples are anticipated, contingent on their status in the local ecology (e.g., willow leaves/stems might be consumed by grazers but roots would not be consumed; whole beetles would be consumed by predators).				
Basis for Selection: Collecting and analyzing whole plants/animals and select plant/animal parts from seep-influenced areas and control areas would provide insight regarding the overall environmental influence of the COCs present in the seeps and areas influenced by the seeps.				

A7.2 STATISTICAL DESIGN

Tables A7-4 through A7-8 have been completed for those DSs requiring a statistical approach. For each DS, these tables identify the statistical hypothesis test selected for testing the null hypothesis, present the formula for calculating the required number of samples/measurements, identify the total number of samples/measurements to be collected and estimated cost for various Type I (alpha) and Type II (beta) error tolerances, present the results from a trade-off analysis, and summarize of the final selected statistical sampling/measurement design.

A7.2.1 Data Collection Design Alternatives

Table A7-4 identifies the statistical design alternatives (i.e., simple random, stratified random, and systematic) that were evaluated for each DS, as well as the selected design and the basis for the selection.

Table A7-4. Selected Statistical Design.

DS #	Media	Statistical Design Alternatives
Not applicable		
Selected Statistical Design:		
Basis for Selection:		

A7.2.2 Mathematical Expressions for Solving Design Problems

Table A7-5 identifies the statistical hypothesis test (e.g., Wilcoxon Signed Rank Test or One Sample t-Test) that has been selected for testing the null hypothesis. The table presents the assumptions that were made about the population distribution (i.e., symmetrical or normal) in the selection process, as well as the formula for calculating the required number of samples/ measurements.

Table A7-5. Statistical Methods for Testing the Null Hypothesis.

DS #	Media	Statistical Method Alternatives	Selected Statistical Method for Testing Null Hypothesis	Assumptions Made in Selecting Statistical Method	Formula for Calculating Number of Samples/ Measurements
Not applicable					

A7.2.3 Select the Optimal Sample/Measurement Size that Satisfies the Data Quality Objectives

Table A7-6 presents the total number of samples/measurements required to be collected for each DS with varying error tolerances and varying widths of the gray region. The total number of samples/measurements was calculated using the statistical method identified in Table A7-4. As would be expected, the higher the error tolerances and wider the gray region, the smaller the number of samples/measurements that are required.

Table A7-6. Sample/Measurement Size Based on Varying Error Tolerances and LBGR. (2 Pages)

	Mistakenly Concluding < Action Level		
	$\alpha =$	$\alpha =$	$\alpha =$
DS # = N/A			
LBGR = N/A			

Table A7-6. Sample/Measurement Size Based on Varying Error Tolerances and LBGR. (2 Pages)

		Mistakenly Concluding < Action Level		
		α =	α =	α =
Mistakenly Concluding > Action Level	β=			
	β=			
	β=			

N/A = not applicable

A7.2.4 Sampling/Measurement Cost

For varying error tolerances, and varying widths of the gray region, Table A7-7 presents the total cost for sampling and analyzing the number of samples identified in Table A7-6. As would be expected, the higher the error tolerances, the wider the gray region, and the lower the sampling and analysis costs.

Table A7-7. Sampling Cost Based on Varying Error Tolerances and LBGR.

		Mistakenly Concluding < Action Level		
		α =	α =	α =
DS # = N/A				
LBGR = N/A				
Mistakenly Concluding > Action Level	β=			
	β=			
	β=			

N/A = not applicable

A7.2.5 Selecting the Most Resource-Effective Data Collection Design

A trade-off analysis was performed for to identify the most resource-optimal number of samples/measurements for the given budget. It is important to consider trade-offs so contingency plans can be developed and the added value of selecting one set of considerations over another can be quantified. Table A7-8 identifies the sampling/measurement design that provides the best balance between cost (and expected cost) and the ability to meet the DQOs, and a selection was made.

Table A7-8. Most Resource-Effective Data Collection Design.

A statistical sampling design was not needed for this project.

A7.3 FINAL SAMPLING DESIGN

The results from the DQO technical team and decision-maker evaluation of the sampling options were assessed for each DS. For each DS, Table A7-9 presents a summary of the final sampling design and the total number of samples needed.

Table A7-9. Final DQO Statistical Sampling/Measurement Design. (2 Pages)

DS #	Statistical Sampling/Measurement Design	Number of Samples/ Measurements	Total Number of Samples/ Measurements Within Population
2 and 3	Monitor existing/new wells semi-annually. Semi-annual monitoring would provide sufficient data to evaluate plume status, COC trends, and the effectiveness of MNA either through trend analysis or modeling. Quarterly sampling for new monitoring wells is advised to develop a water quality baseline. Tributyl phosphate (316-4 crib) and nitrate (all locations) analysis should be considered for plume tracking and general water quality purposes.	• 2 samples/year from each well: – 618-11 Burial Ground: ~5 wells – 618-10 Burial Ground/ 316-4 Crib:~5 wells – 300-FF-2 OU and 399-3-10 vicinity: ~20 wells • 2 samples/year x ~30 wells = ~60 samples/year	Infinite
3 and 4	Annual grab samples from seeps and adjacent river areas during low-flow periods. Analyze for COCs plus hardness (to assess river water proportion of seep water). Annual grab samples from individual seeps and their adjacent river areas during low river stage would provide an assessment of seep/river water quality and an evaluation of MCL/AWQC compliance under worst-case conditions.	• 1 sample/year from each seep during river low-flow periods (September or October) • 3 seeps would be sampled • 1 sample/year x 3 seeps = 3 samples/year	

Table A7-9. Final DQO Statistical Sampling/Measurement Design. (2 Pages)

DS #	Statistical Sampling/Measurement Design	Number of Samples/ Measurements	Total Number of Samples/ Measurements Within Population
4	Collect/analyze whole plants/animals and select plant/animal parts from seep-influenced areas and control areas. Whole plant/animal samples are anticipated for aquatic biota because the expected plants (algae) and animals (freshwater clams) living in the seeps are eaten whole by grazers/predators and cannot be easily dissected into significant parts. Whole and partial terrestrial plant samples are anticipated, contingent on their status in the local ecology (e.g., willow leaves/stems might be consumed by grazers but roots would not be consumed; whole beetles would be consumed by predators). Collecting and analyzing whole plants/animals and select plant/animal parts from seep-influenced areas and control areas would provide insight regarding the overall environmental influence of the COCs present in the seeps and areas influenced by the seeps.	• 3 seep-influenced samples and 1 control area sample per biota species annually (i.e., September or October) before leaf-fall • Assume 2 aquatic and 2 terrestrial species (1 plant and 1animal) per seep • 3 seeps would be sampled • 3 species x 3 seeps x 1 sample period = 3 samples/year	Infinite

A8.0 REFERENCES

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 U.S.C. 9601, et seq.

DOE-RL, 1993, *Phase I and II Feasibility Study for the 300-FF-1 Operable Unit*, DOE/RL-92-46, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1995, *Remedial Investigation/Feasibility Study Report for the 300-FF-5 Operable Unit*, DOE/RL-94-85, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1996, *Operation and Maintenance Plan for the 300-FF-5 Operable Unit*, DOE/RL-95-73, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2000, *Focused Feasibility Study for the 300-FF-2 Operable Unit*, DOE/RL-99-40, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

EPA, 2001, *USDOE Hanford Site First Five-Year Review Report*, Public Review Draft, U.S. Environmental Protection Agency, Region 10, Kennewick, Washington.

EPA, Ecology, and DOE, 2000, *Explanation of Significant Difference (ESD) for the 300-FF-5 Record of Decision*, U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington.

PNNL, 1997, *Hanford Site Groundwater Monitoring for Fiscal Year 1996*, PNNL-11470, Pacific Northwest National Laboratory, Richland, Washington.

PNNL, 1998, *Hanford Site Groundwater Monitoring for Fiscal Year 1997*, PNNL-11793, Pacific Northwest National Laboratory, Richland, Washington.

PNNL, 1999, *Hanford Site Groundwater Monitoring for Fiscal Year 1998*, PNNL-12086, Pacific Northwest National Laboratory, Richland, Washington.

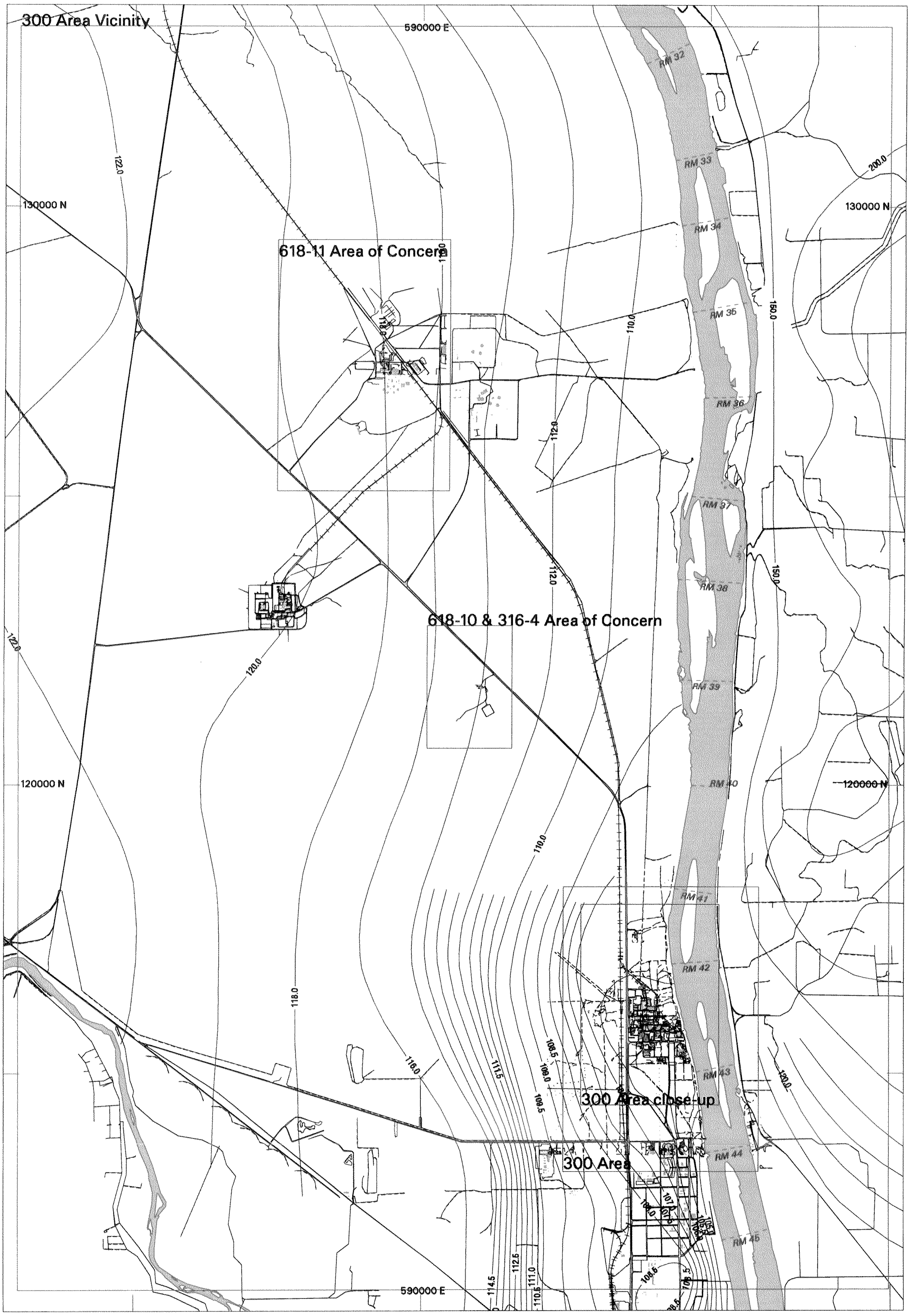
PNNL, 2000, *Hanford Site Groundwater Monitoring for Fiscal Year 1999*, PNNL-13116, Pacific Northwest National Laboratory, Richland, Washington.

Resource Conservation and Recovery Act of 1976, 42 U.S.C. 6901, et seq.

APPENDIX B

300 AREA DRAWINGS AND MAPS

Index map



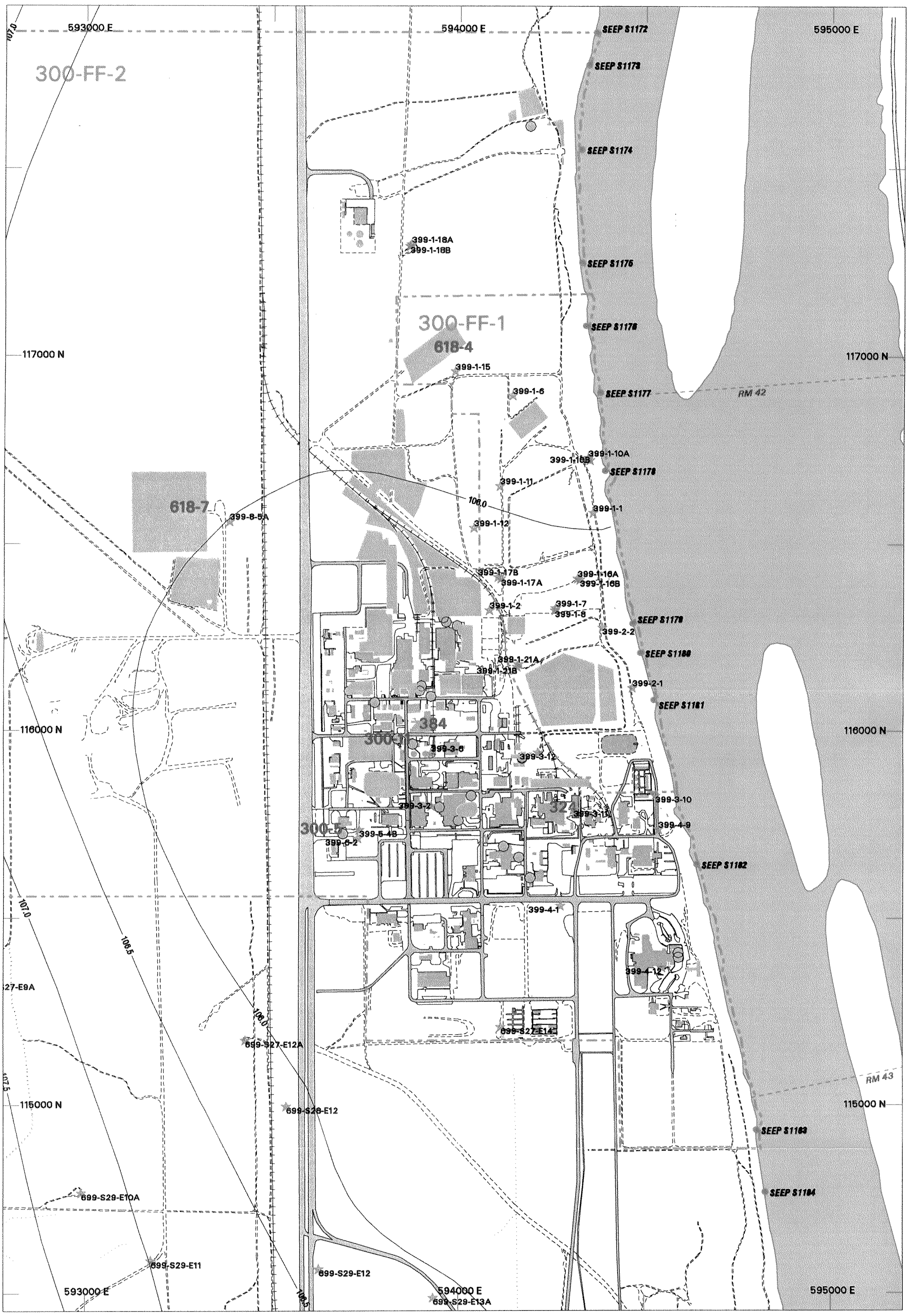
Water table See Note #1
Building
Inset maps
Paved road, sidewalk, etc.
Paved surface
Unpaved road, track, etc.
Trail
Railroad

HANFORD

Note #1: *Water table contours (m above sea level) are discontinuous and shown where available.*

General Note: *The 300-FF-5 Operable Unit is the groundwater influenced by the 300-FF-1&2 source Operable Unit Waste sites.*

Wells 300 Area close-up



N

200 m

OPERABLE UNIT
300-FF-1 and 300-FF-2 source Operable Unit Waste sites
300-5 Area of Concern
300-FF-5 Monitoring Plan Wells

Water table See Note #1
Seep (ID.)
Building
RM 42 River Miles

Paved road, sidewalk, etc.
Paved surface
Railroad

Environmental Excellence
HANFORD

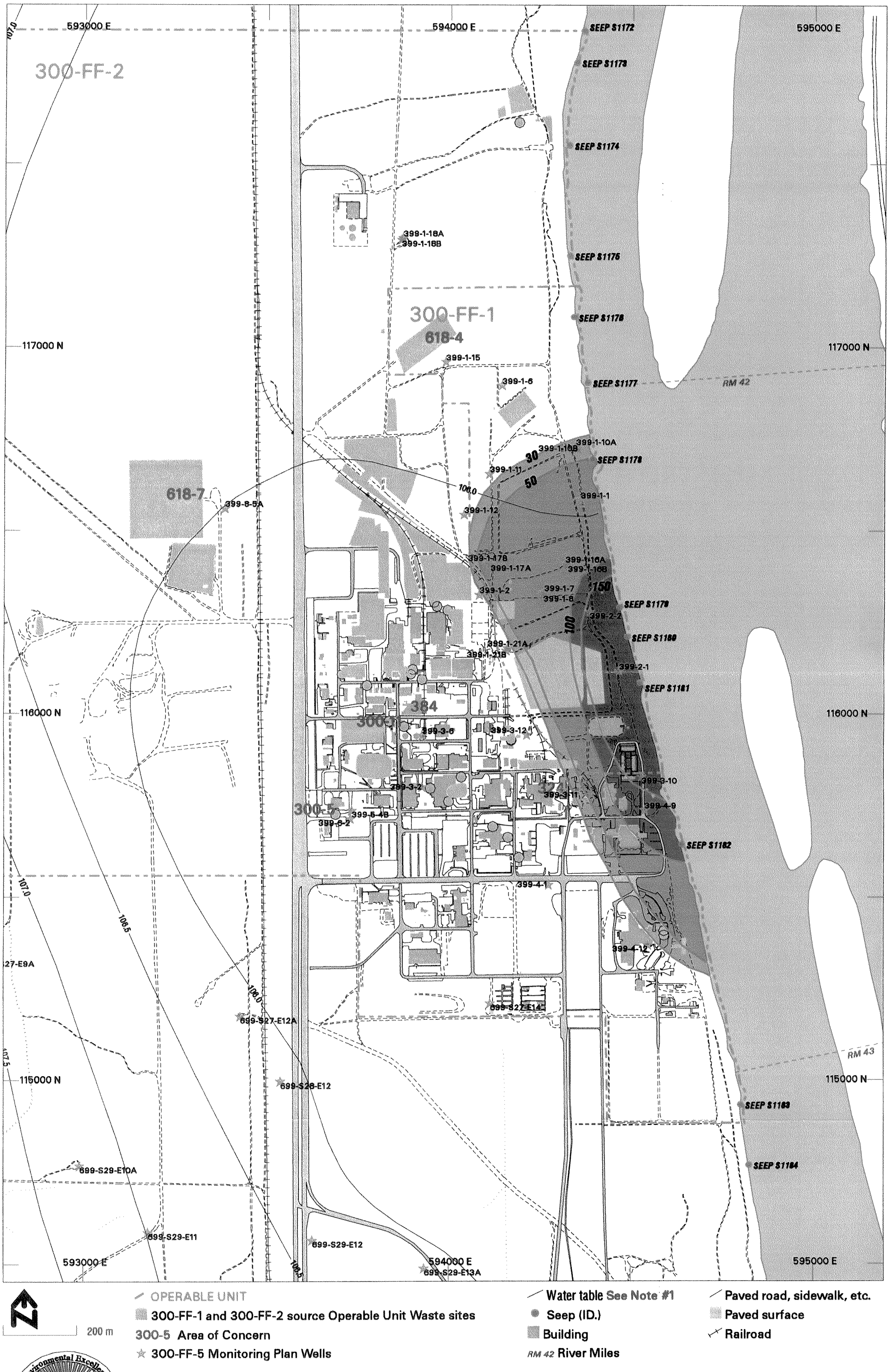
Note #1: *Water table contours (m above sea level) are discontinuous and shown where available.*
General Note: *The 300-FF-5 Operable Unit is the groundwater influenced by the 300-FF-1&2 source Operable Unit Waste sites.*

TWH:03/05/02:chemtill23.aml:23 coc_wel_map_4_5-3

Uranium 300 Area close-up

[The MCL for Uranium is 30 ug/L. See Table 5-3 in text.]

30 - 50 ug/L | 50 - 100 ug/L | 100 - 150 ug/L | 150 - 500 ug/L



Note #1: *Water table contours (m above sea level) are discontinuous and shown where available.*

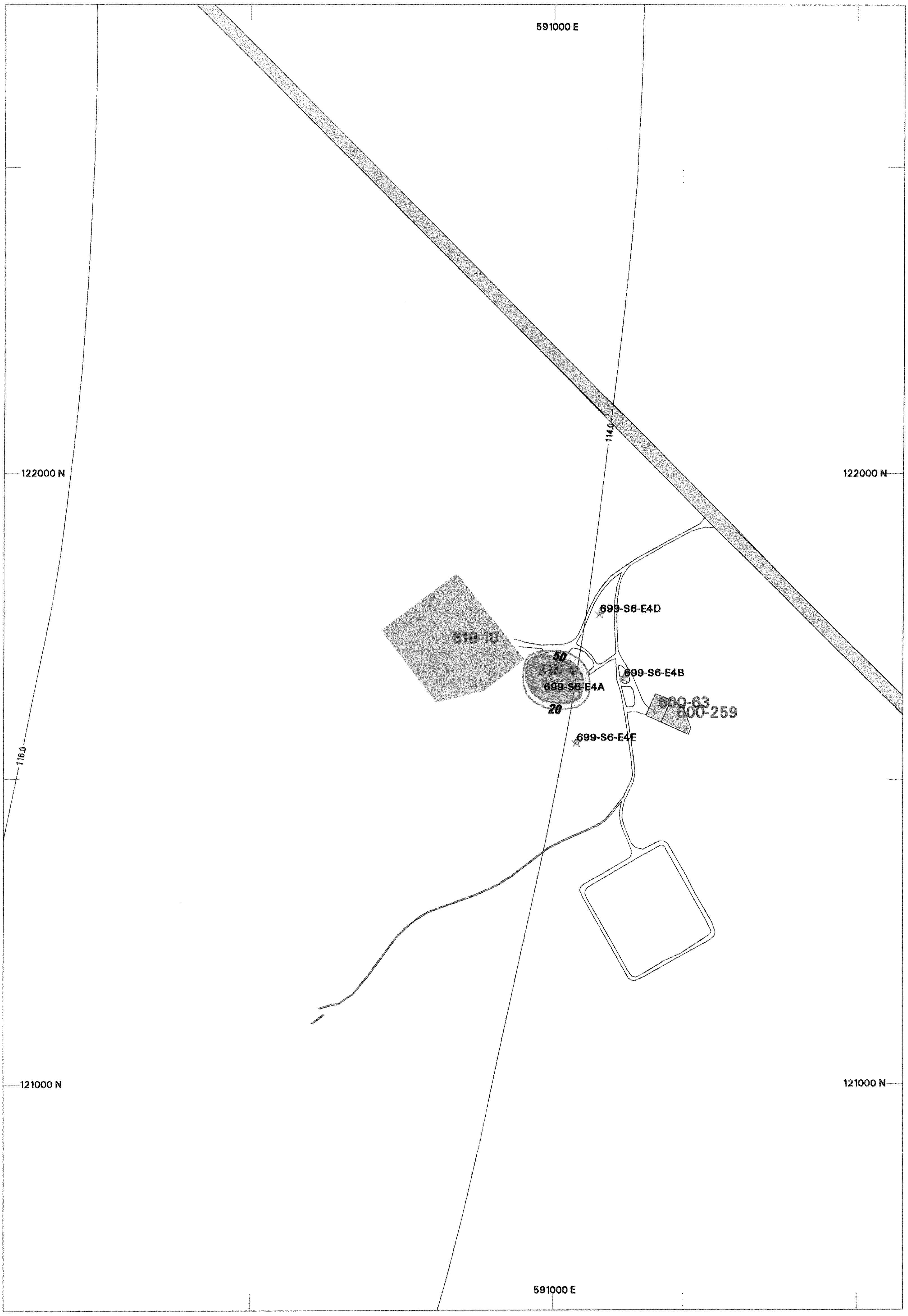
General Notes: *The 300-FF-5 Operable Unit is the groundwater influenced by the 300-FF-1&2 source Operable Unit Waste sites.*
The Contaminant plume data were derived from 'Hanford Site Groundwater Monitoring for Fiscal Year 2001' (PNNL-13788).

TWH:03/05/02:chanstl29.amt:23 coc_urs_map_4_5-3

Uranium 618-10 & 316-4 Area of Concern

[The MCL for Uranium is 30 ug/L. See Table 5-3 in text.]

20 - 50 ug/L   *50 - 100 ug/L*



300-FF-1 and 300-FF-2 source Operable Unit Waste sites

300-5 Area of Concern

300-FF-5 Monitoring Plan Wells

Water table See Note #1

Paved road, sidewalk, etc.

Paved surface

100 m

HANFORD

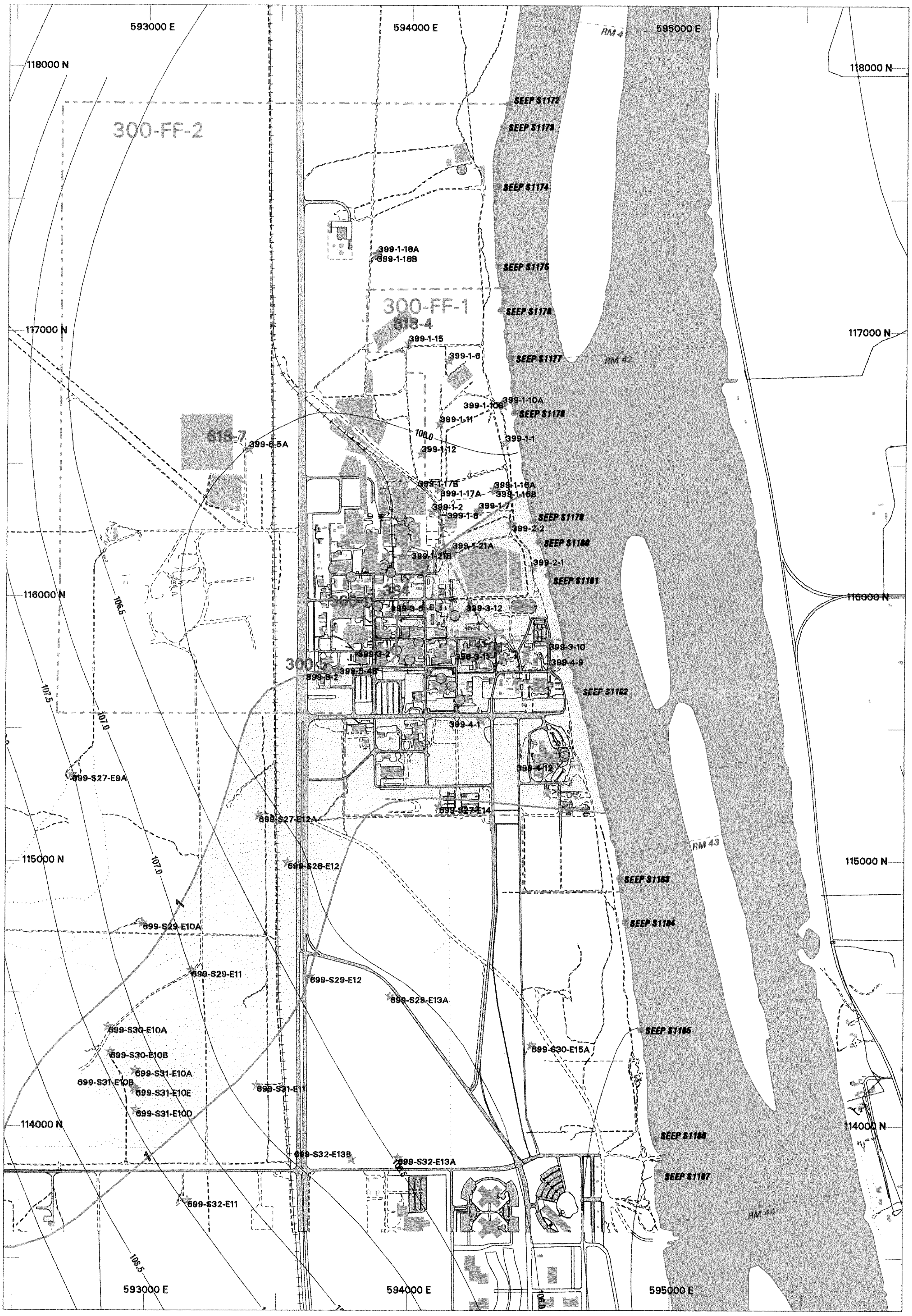
Note #1: *Water table contours (m above sea level) are discontinuous and shown where available.*

General Notes: *The 300-FF-5 Operable Unit is the groundwater influenced by the 300-FF-1&2 source Operable Unit Waste sites.*
The Contaminant plume data were derived from 'Hanford Site Groundwater Monitoring for Fiscal Year 1999' (PNNL-13116).

Trichloroethylene 300 Area

[The MCL for Trichloroethylene is 3.98 ug/L. See Table 5-3 in text.]

1 - 5 ug/L



250 m

OPERABLE UNIT
300-FF-1 and 300-FF-2 source Operable Unit Waste sites
300-5 Area of Concern
300-FF-5 Monitoring Plan Wells

Water table See Note #1
Seep (ID.)
Building
RM 42 River Miles

Paved road, sidewalk, etc.
Paved surface
Unpaved road, track, etc.
Trail
Railroad

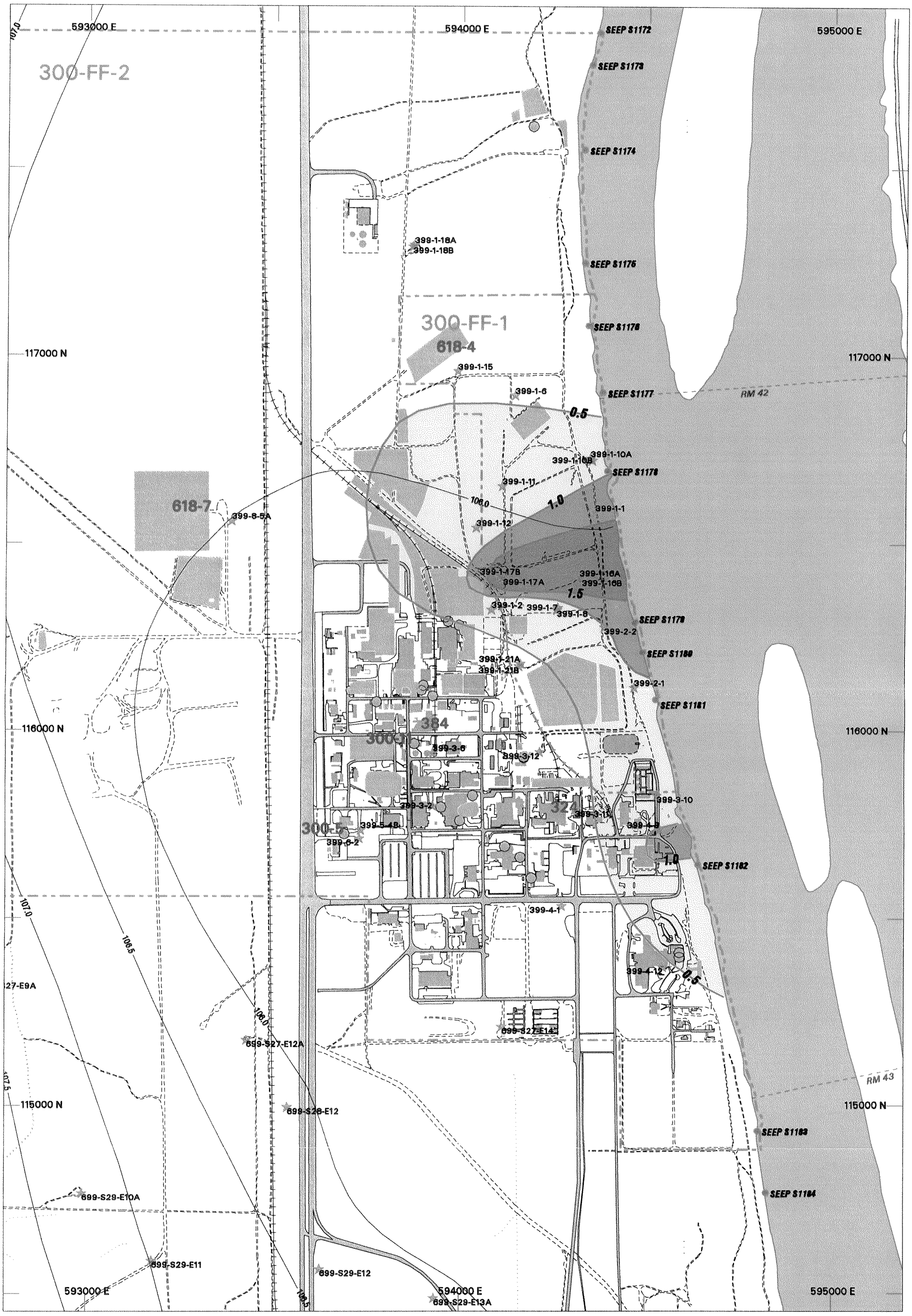
Environmental Excellence
HANFORD

Note #1: *Water table contours (m above sea level) are discontinuous and shown where available.*
General Notes: *The 300-FF-5 Operable Unit is the groundwater influenced by the 300-FF-1&2 source Operable Unit Waste sites.*
The Contaminant plume data were derived from 'Hanford Site Groundwater Monitoring for Fiscal Year 2001' (PNNL-13788).

Tetrachloroethylene 300 Area close-up

[The MCL for Tetrachloroethylene is 0.858 ug/L. See Table 5-3 in text.]

0.5 - 1.0 ug/L *1.0 - 1.5 ug/L* *> 1.5 ug/L*



OPERABLE UNIT
300-FF-1 and 300-FF-2 source Operable Unit Waste sites
300-5 Area of Concern
300-FF-5 Monitoring Plan Wells
200 m
Water table See Note #1
Seep (ID.)
Building
RM 42 River Miles
Paved road, sidewalk, etc.
Paved surface
Railroad

HANFORD

TW:\t93/95402:chantill23.wmc23 ooc_pcs_map_4_5-3

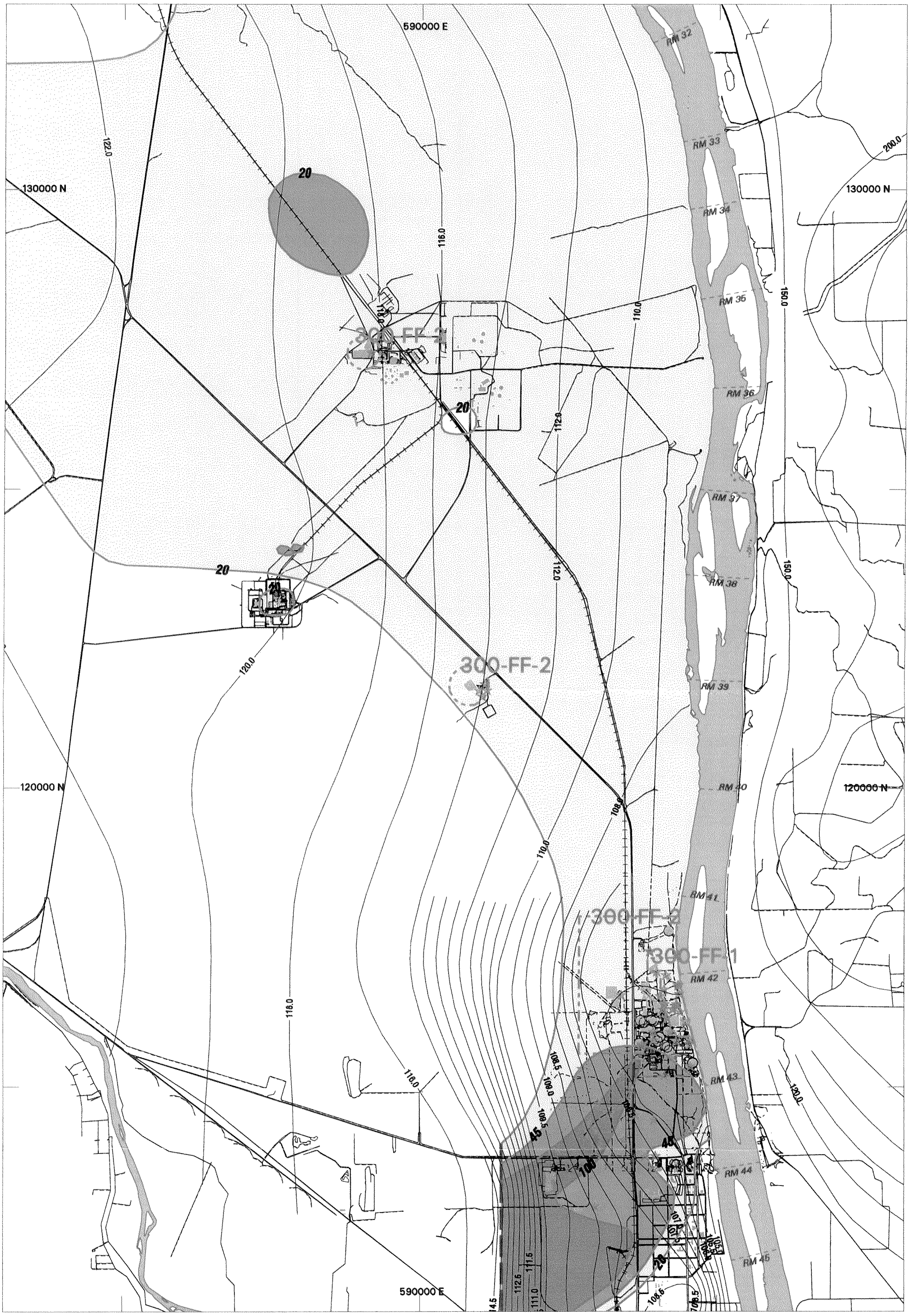
Note #1: *Water table contours (m above sea level) are discontinuous and shown where available.*

General Notes: *The 300-FF-5 Operable Unit is the groundwater influenced by the 300-FF-1&2 source Operable Unit Waste sites.*
The Contaminant plume data were derived from 'Hanford Site Groundwater Monitoring for Fiscal Year 1999' (PNNL-13116).

Nitrate 300 Area Vicinity

[The MCL for Nitrate is 10 mg/L. See Table 5-3 in text.]

20 - 45 mg/L | *45 - 100 mg/L* | *> 100 mg/L* | *edge of available plume data*



1000 m

OPERABLE UNIT
300-FF-1 and 300-FF-2 source Operable Unit Waste sites
300-5 Area of Concern
300-FF-5 Monitoring Plan Wells See Note #2

Water table See Note #1
Building
RM 42 River Miles

Paved road, sidewalk, etc.
Paved surface
Unpaved road, track, etc.
Trail
Railroad

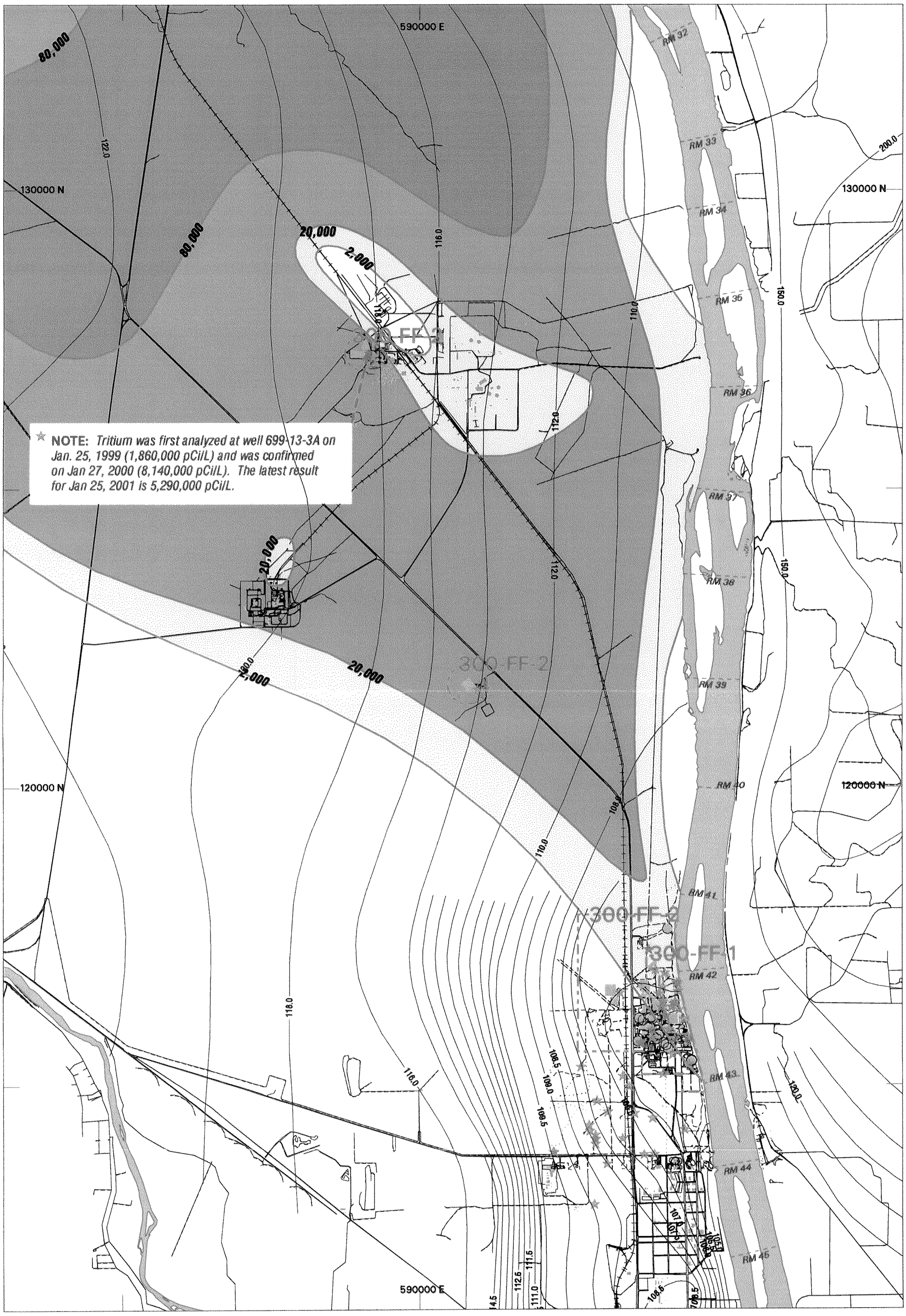
HANFORD

Note #1: *Water table contours (m above sea level) are discontinuous and shown where available.*
Note #2: *Identified on the inset maps*
General Notes: *The 300-FF-5 Operable Unit is the groundwater influenced by the 300-FF-1&2 source Operable Unit Waste sites. The Contaminant plume data north and south of River Mile 42 were derived from different vintage sources. The northern data were derived from 'Hanford Site Groundwater Monitoring for Fiscal Year 1999' (PNNL-13116), The southern data were derived from 'Hanford Site Groundwater Monitoring for Fiscal Year 2001' (PNNL-13788).*

Tritium 300 Area Vicinity

[The MCL for Tritium is 20,000 pCi/L. See Table 5-3 in text.]

2,000 - 20,000 pCi/L ***20,000 - 80,000 pCi/L*** ***> 80,000 pCi/L***



1000 m

OPERABLE UNIT
300-FF-1 and 300-FF-2 source Operable Unit Waste sites
300-5 Area of Concern
300-FF-5 Monitoring Plan Wells See Note #2

Water table See Note #1
Building
RM 42 River Miles

Paved road, sidewalk, etc.
Paved surface
Unpaved road, track, etc.
Trail
Railroad

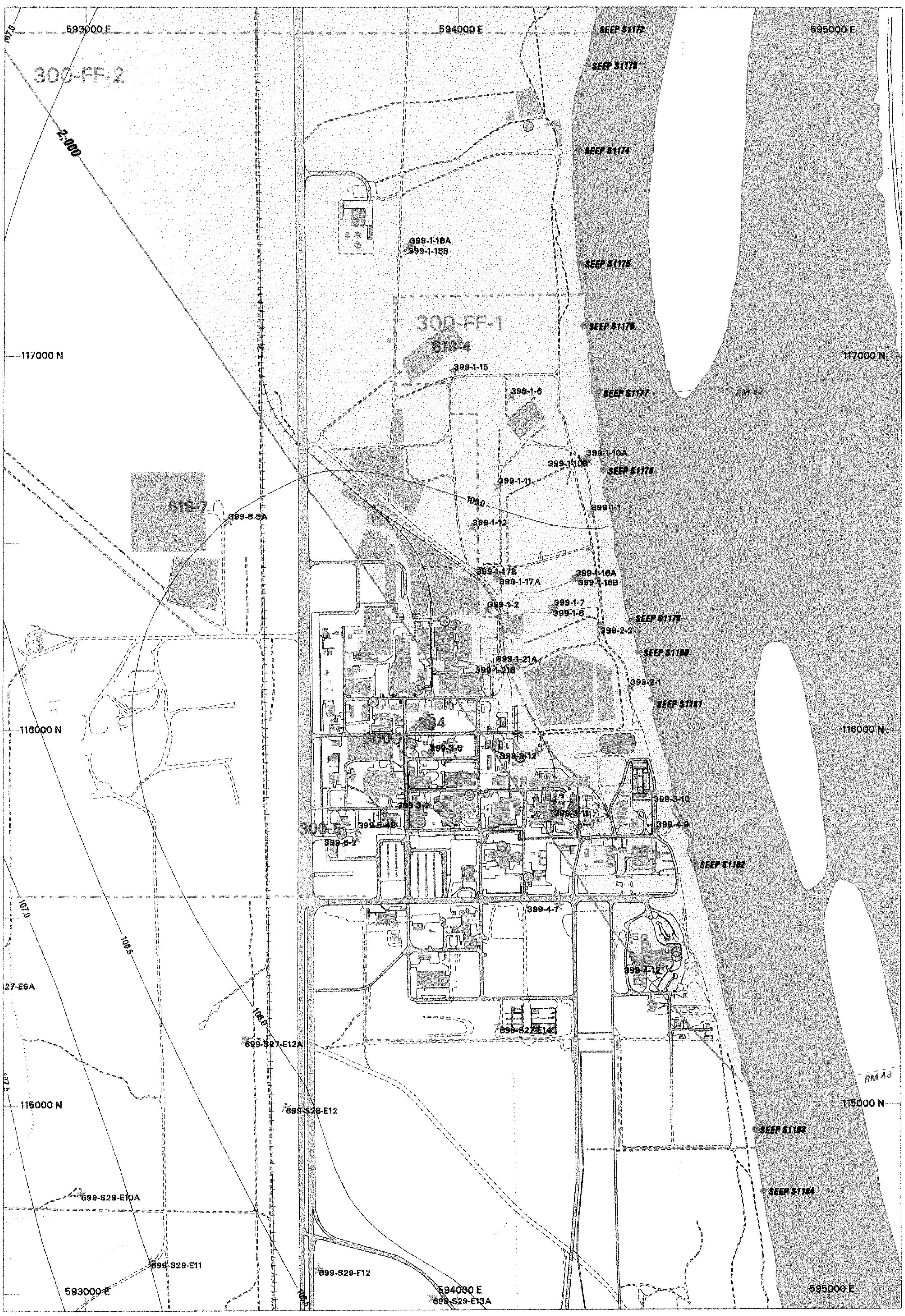
HANFORD

Note #1: *Water table contours (m above sea level) are discontinuous and shown where available.*
Note #2: *Identified on the inset maps*
General Notes: *The 300-FF-5 Operable Unit is the groundwater influenced by the 300-FF-1&2 source Operable Unit Waste sites. The Contaminant plume data were derived from 'Hanford Site Groundwater Monitoring for Fiscal Year 1999' (PNNL-13116).*

Tritium 300 Area close-up

[The MCL for Tritium is 20,000 pCi/L. See Table 5-3 in text.]

2,000 - 20,000 pCi/L



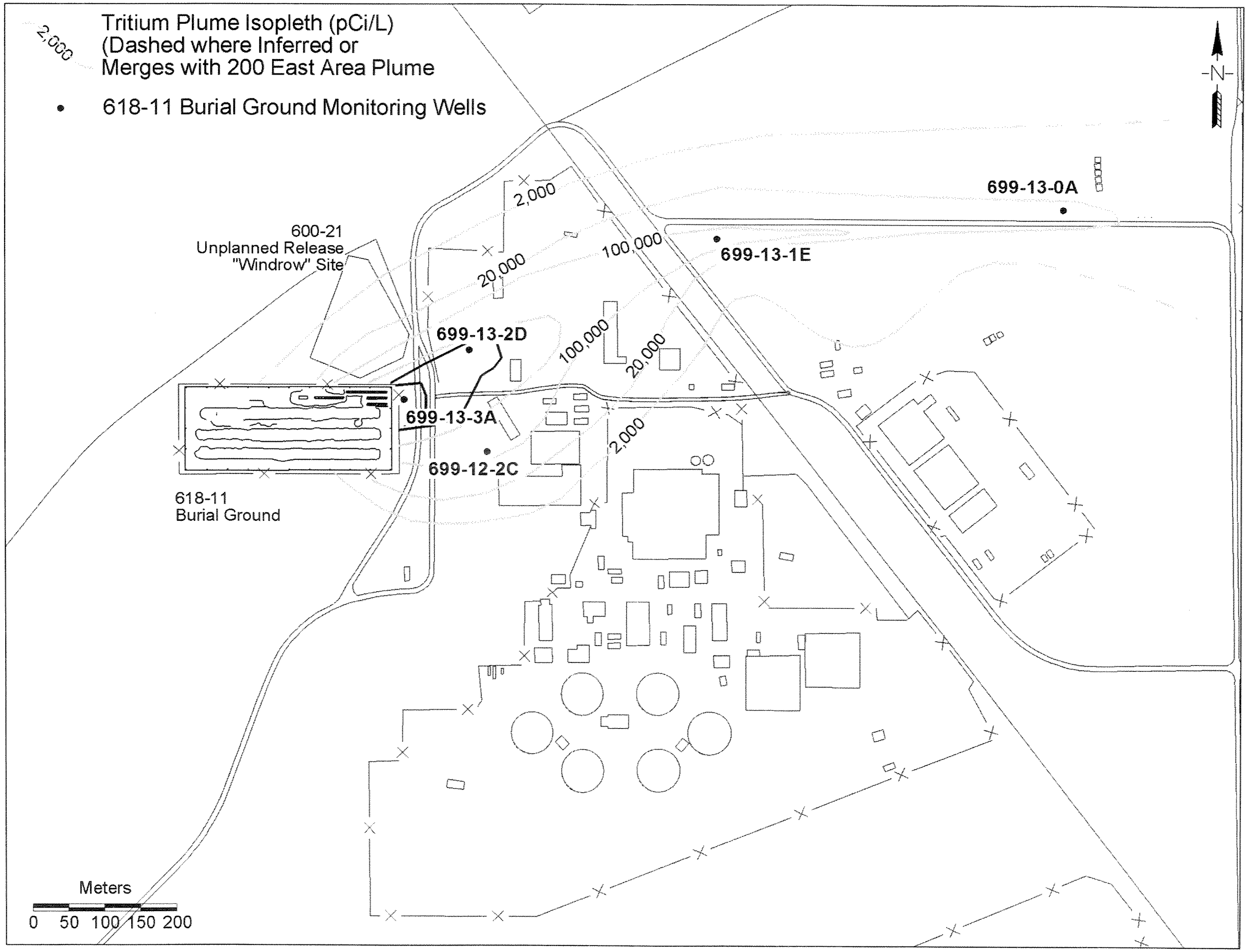
200 m

- OPERABLE UNIT
- 300-FF-1 and 300-FF-2 source Operable Unit Waste sites
- 300-5 Area of Concern
- ★ 300-FF-5 Monitoring Plan Wells
- Water table See Note #1
- ● Seep (ID.)
- Building
- RM 42 River Miles
- Paved road, sidewalk, etc.
- Paved surface
- Railroad

HANFORD

Note #1: *Water table contours (m above sea level) are discontinuous and shown where available.*

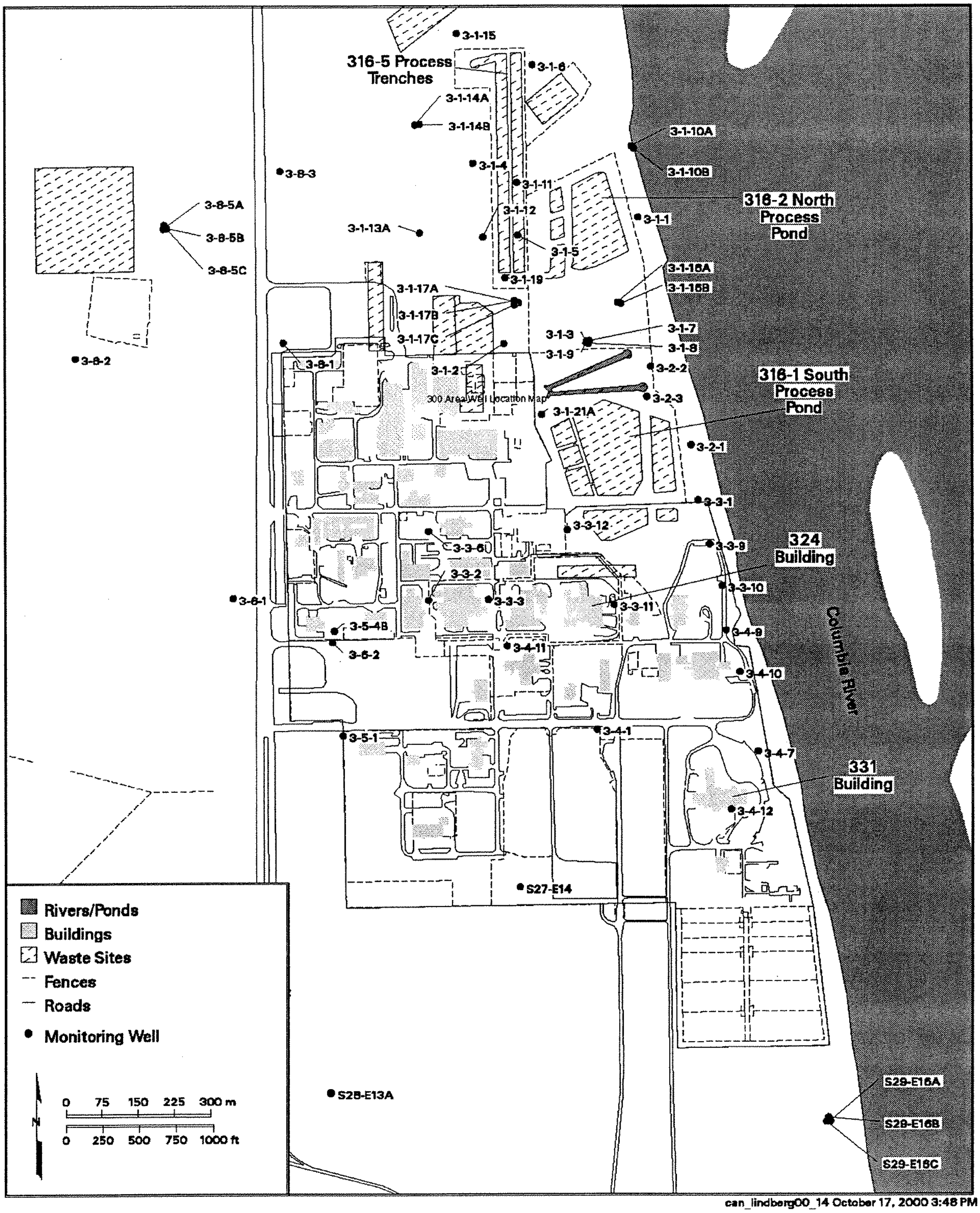
General Notes: *The 300-FF-5 Operable Unit is the groundwater influenced by the 300-FF-1&2 source Operable Unit Waste sites.*
The Contaminant plume data were derived from 'Hanford Site Groundwater Monitoring for Fiscal Year 1999' (PNNL-13116).


Tritium Plume Isopleth (pCi/L)
(Dashed where Inferred or
Merges with 200 East Area Plume
2,000
618-11 Burial Ground Monitoring Wells
N
2,000
20,000
100,000
100,000
20,000
2,000
699-13-0A
699-13-1E
699-13-2D
699-13-3A
699-12-2C
600-21
Unplanned Release
"Windrow" Site
618-11
Burial Ground
Meters
0 50 100 150 200

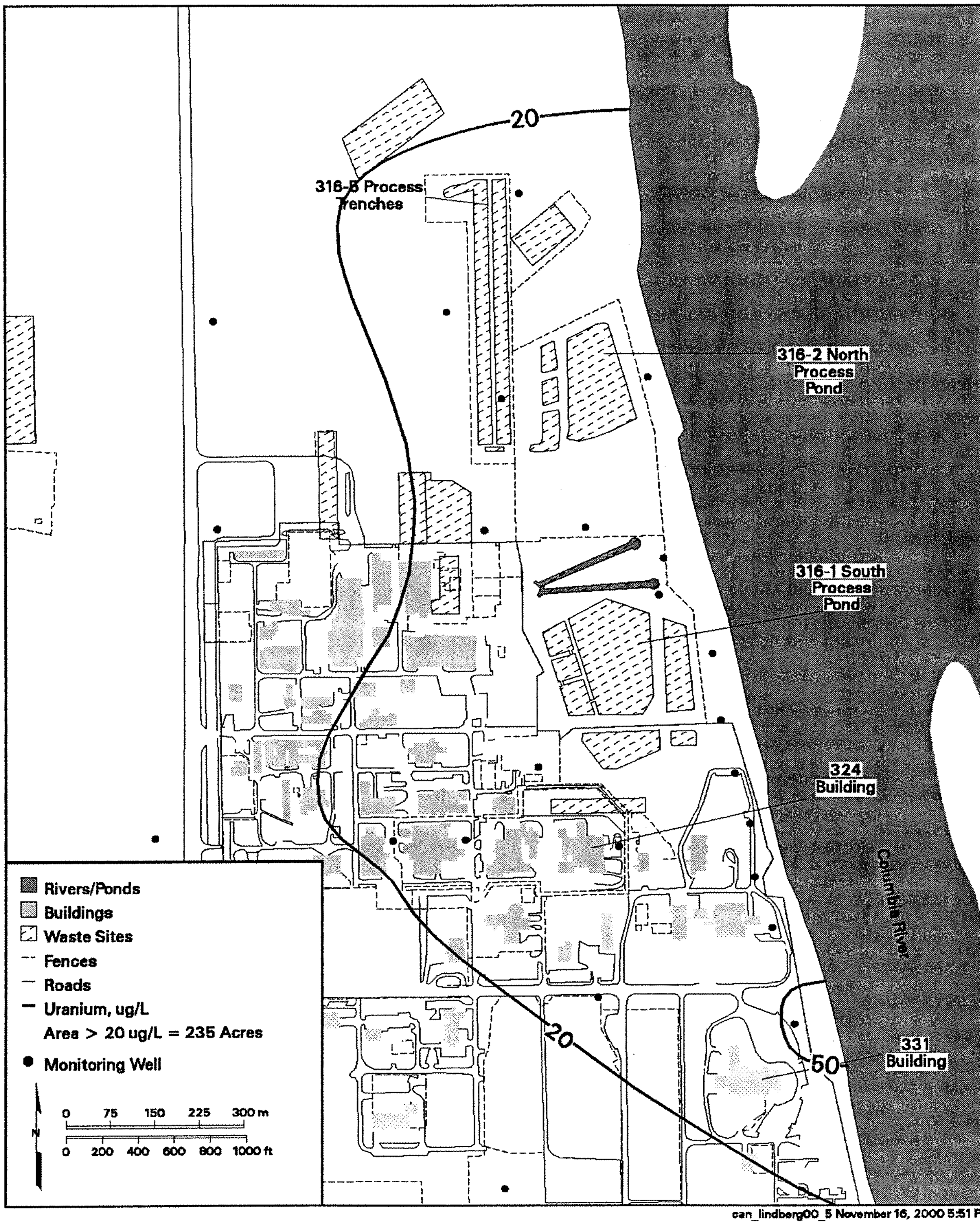
APPENDIX C

HISTORICAL PLUME MAPS

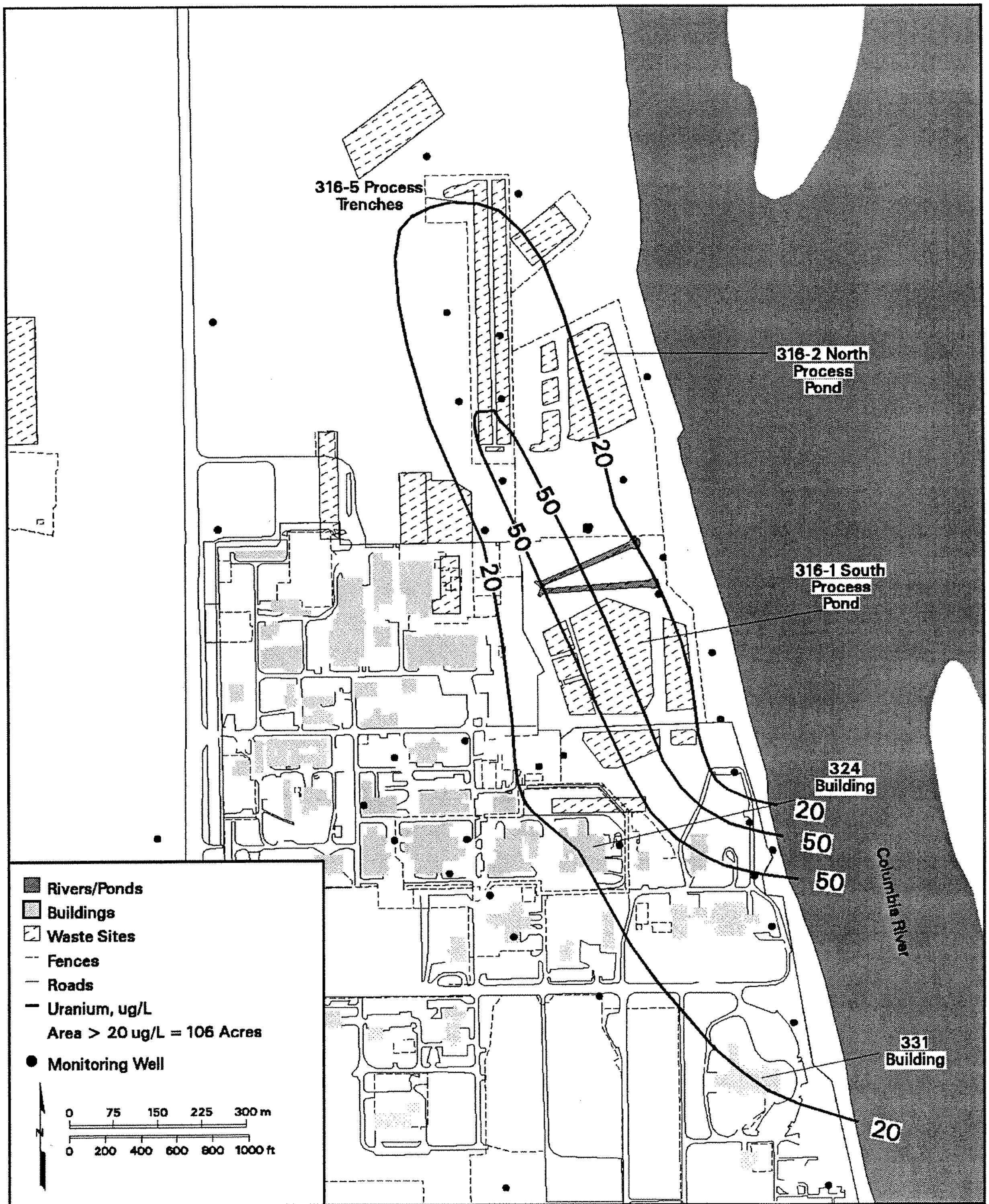
300 Area Well Location Map.



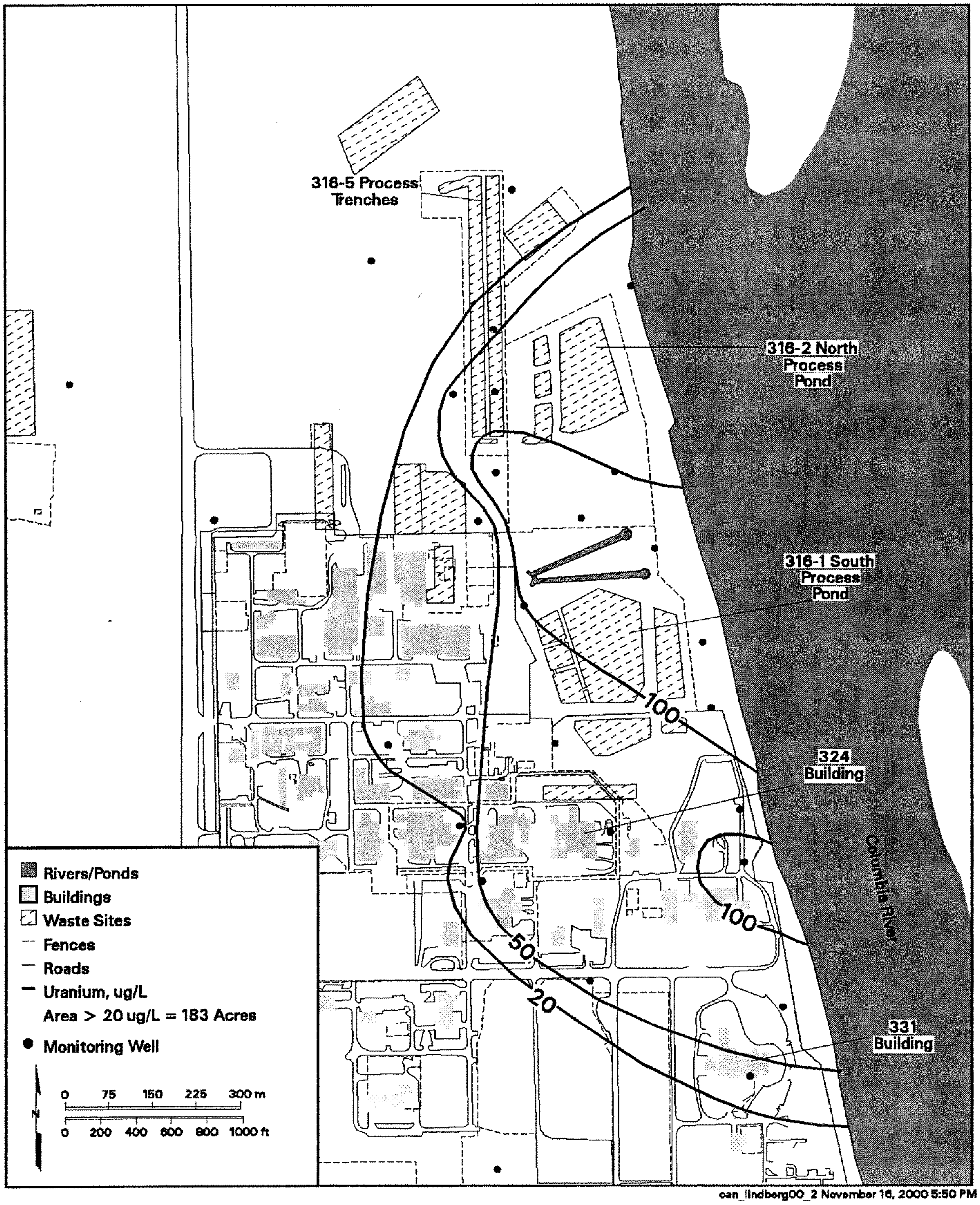
300 Area Uranium Contours for FY1977



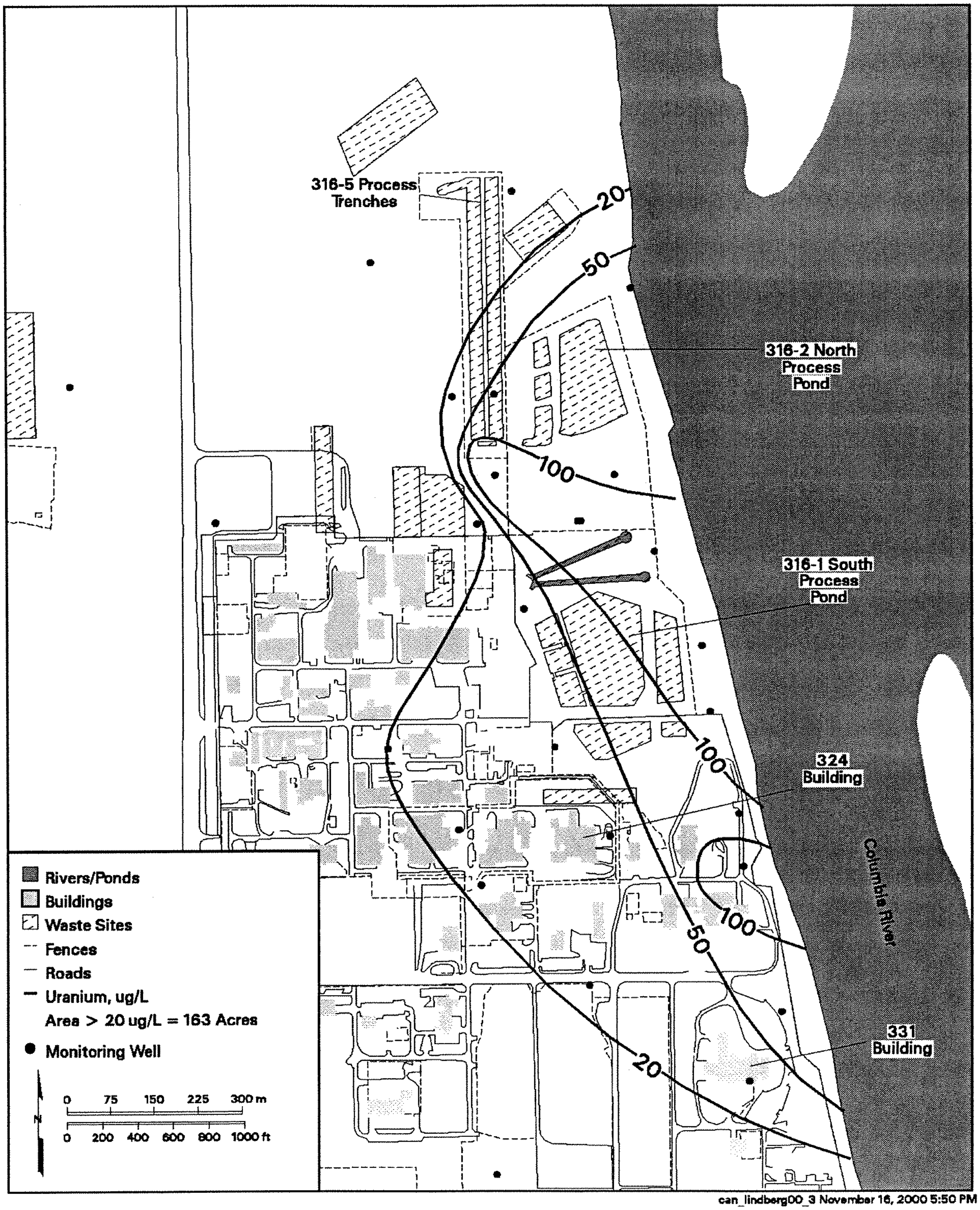
300 Area Uranium Contours for FY1987



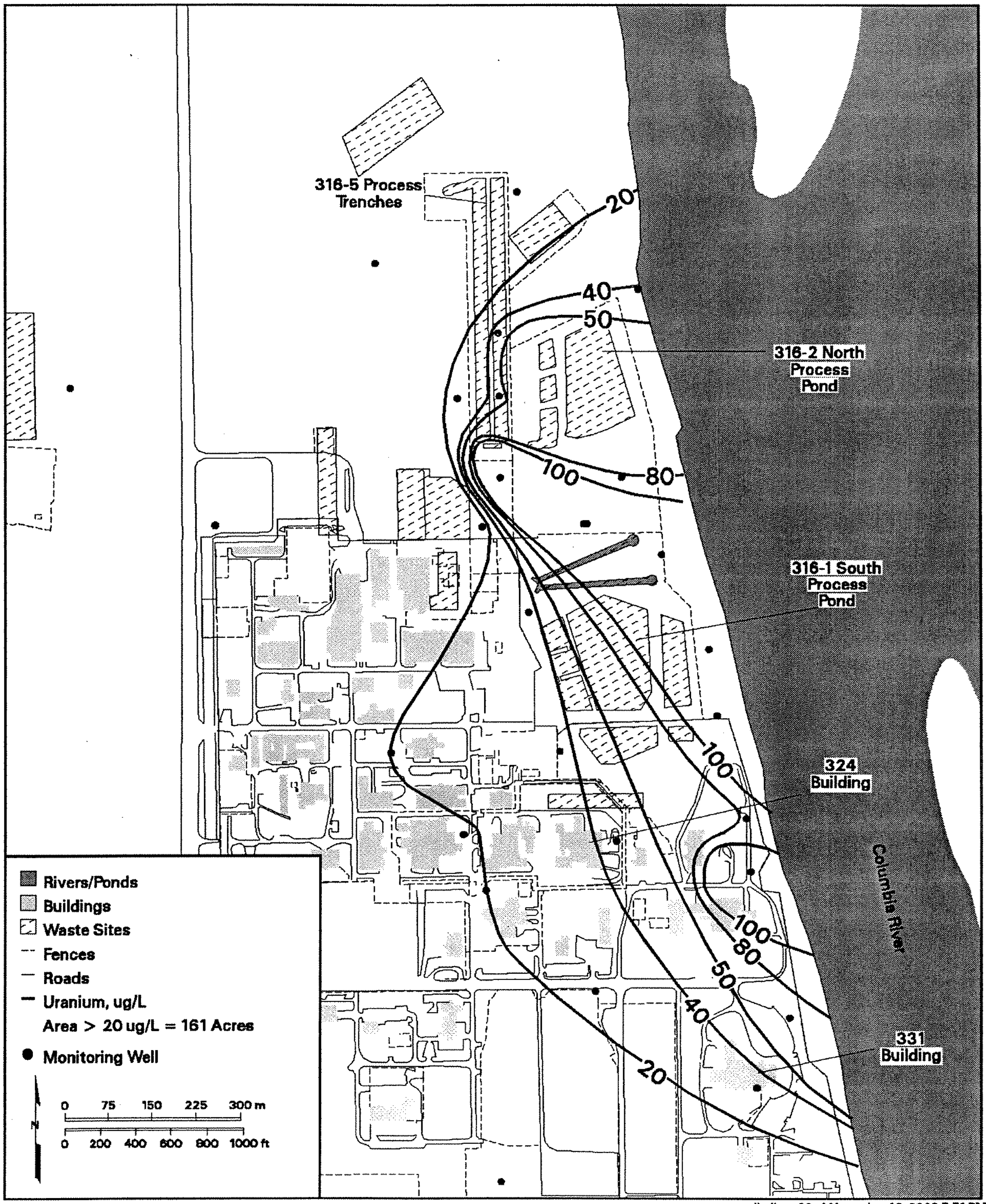
300 Area Uranium Contours for FY1997



300 Area Uranium Contours for FY1998

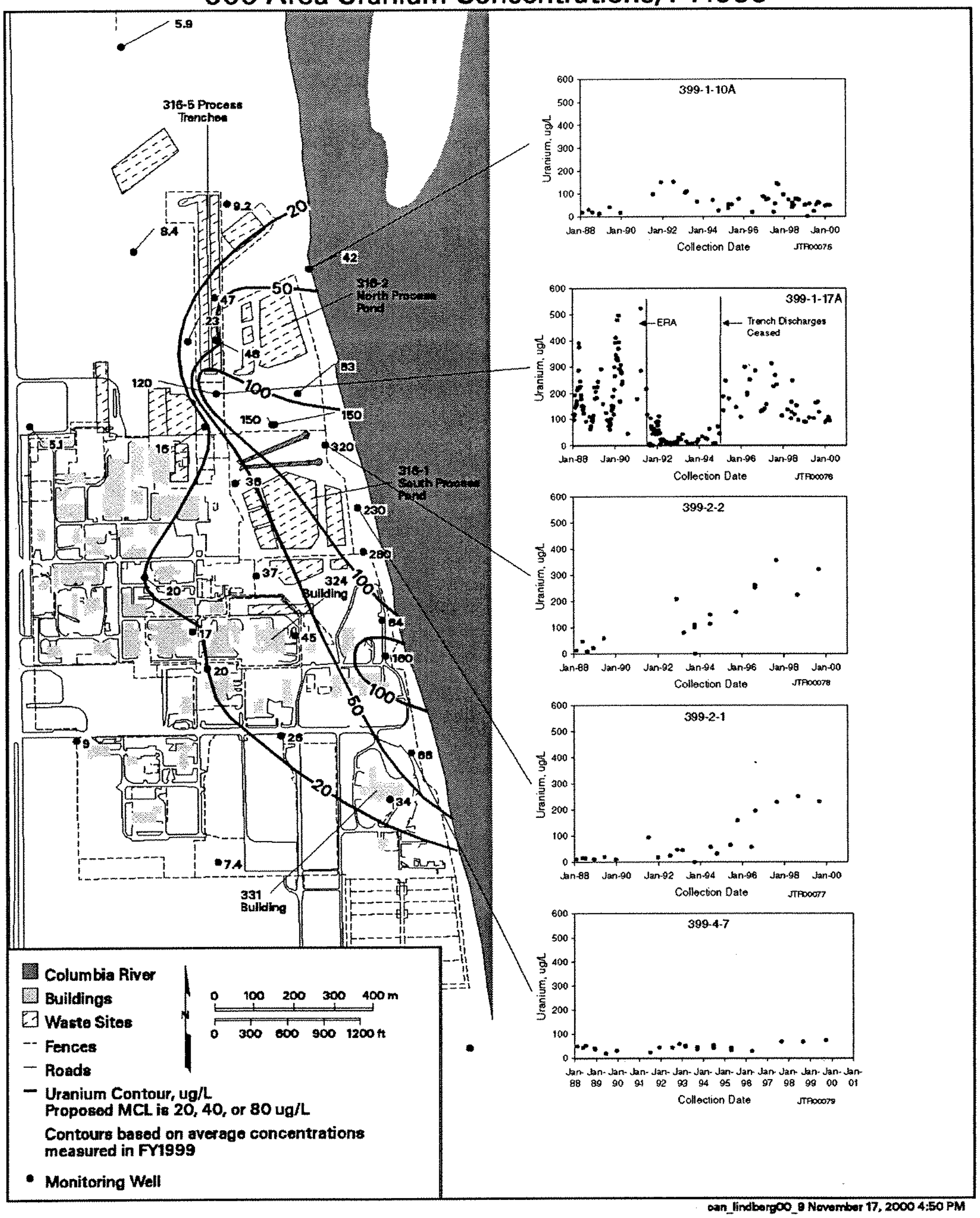


300 Area Uranium Contours for FY1999



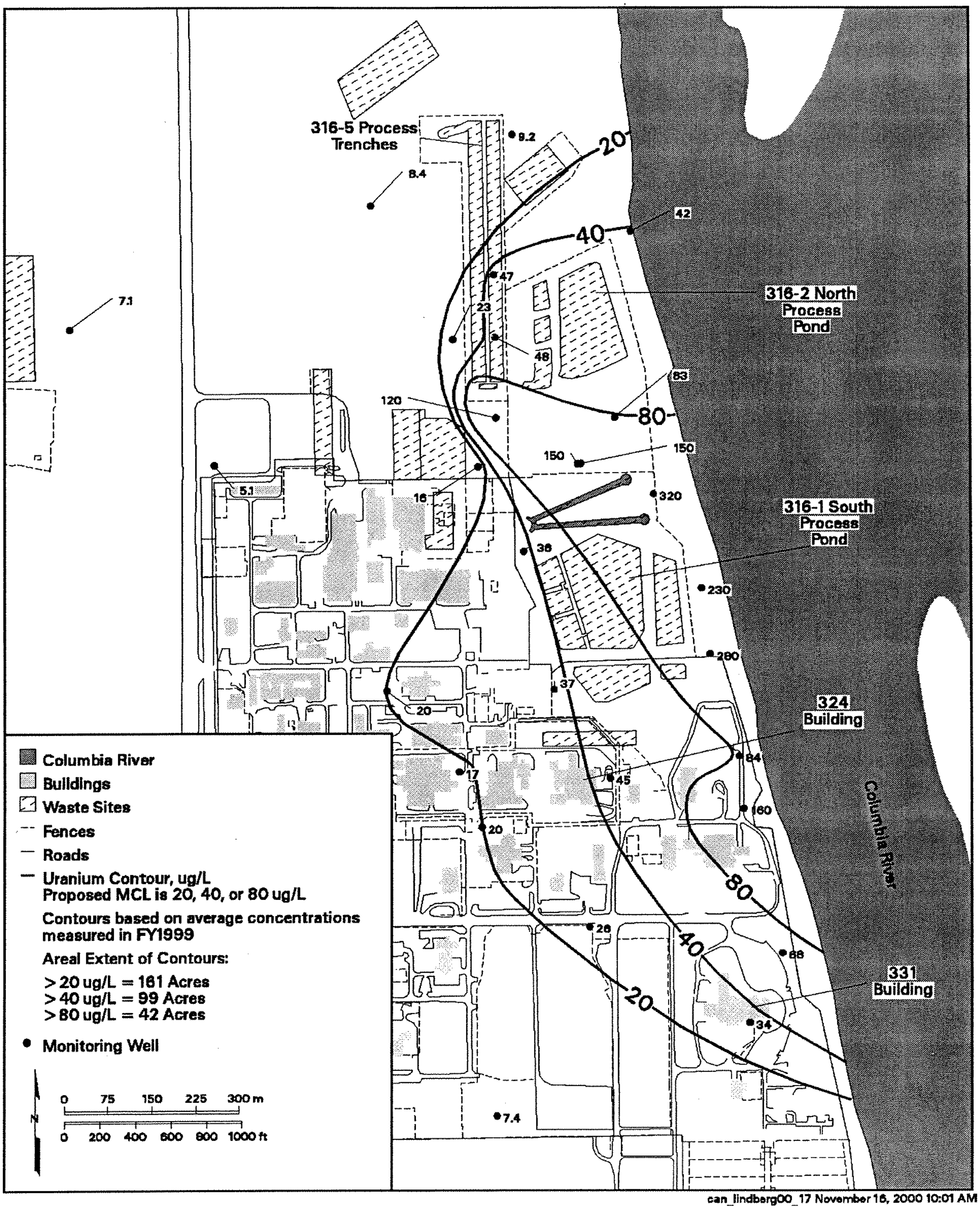
can_lindberg00_4 November 16, 2000 5:51 PM

300 Area Uranium Concentrations, FY1999

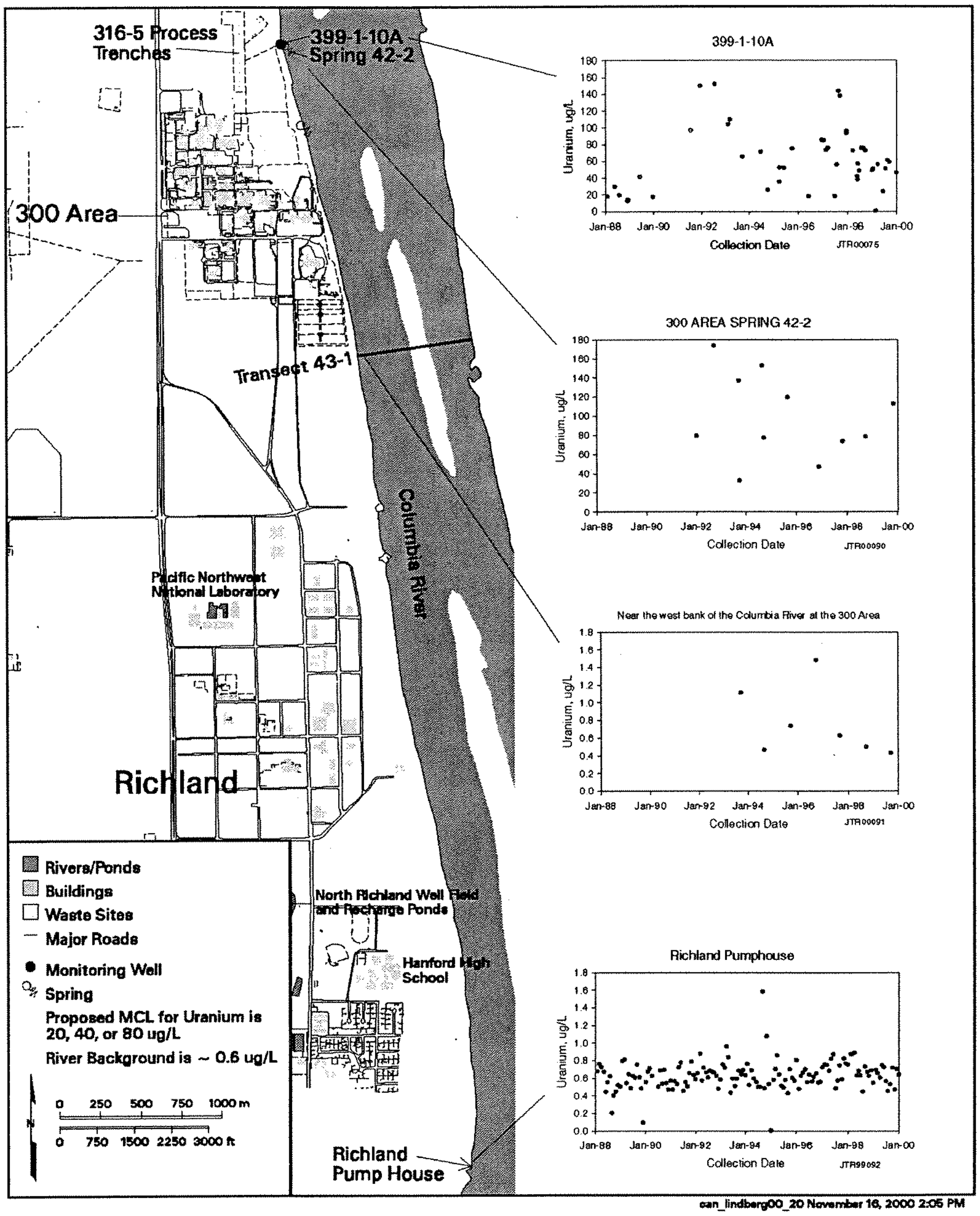


oan_lindberg00_9 November 17, 2000 4:50 PM

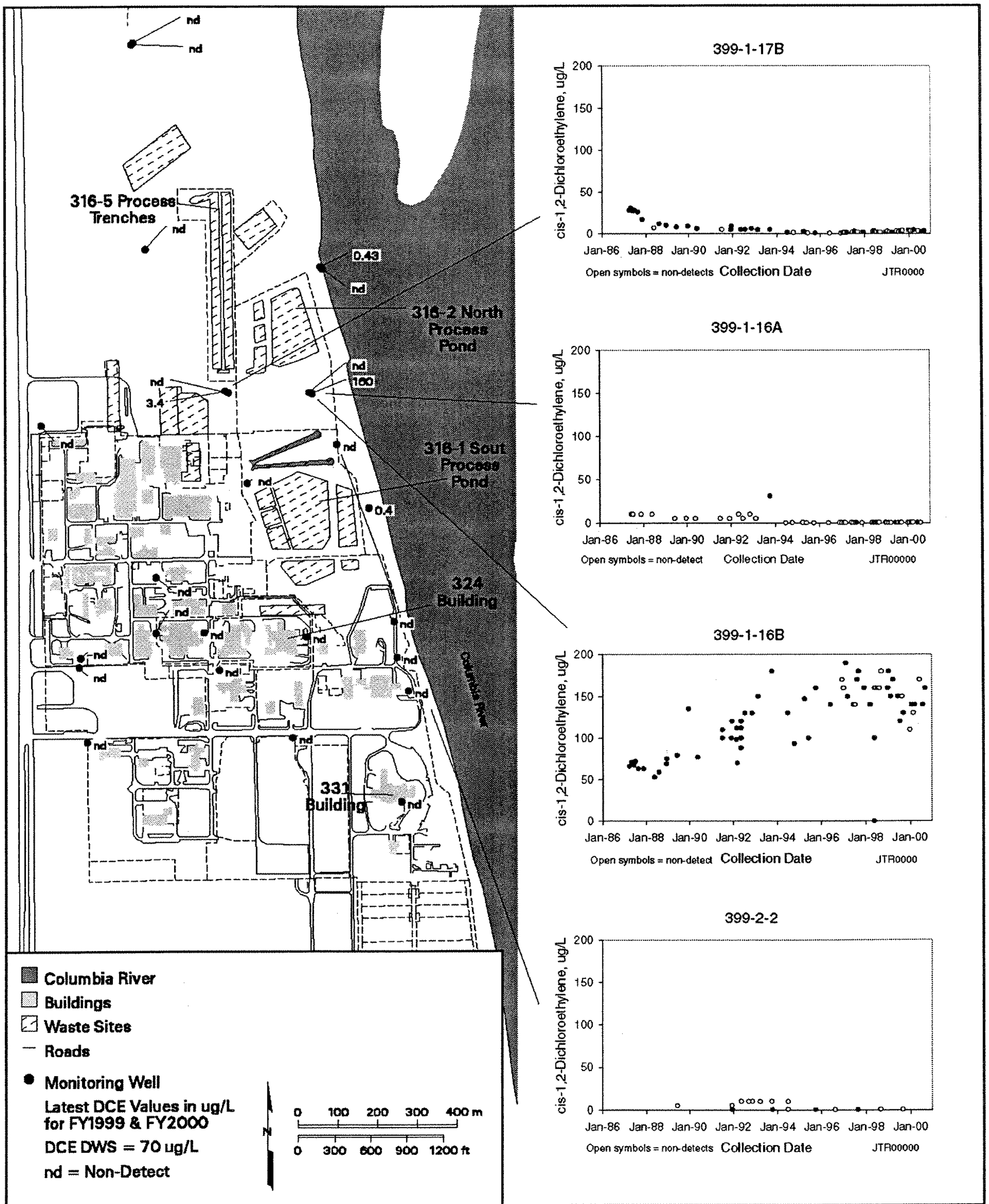
300 Area Uranium Contours for FY1999



Uranium Trends in Groundwater, Spring, and River



300 Area cis-12DCE Concentrations



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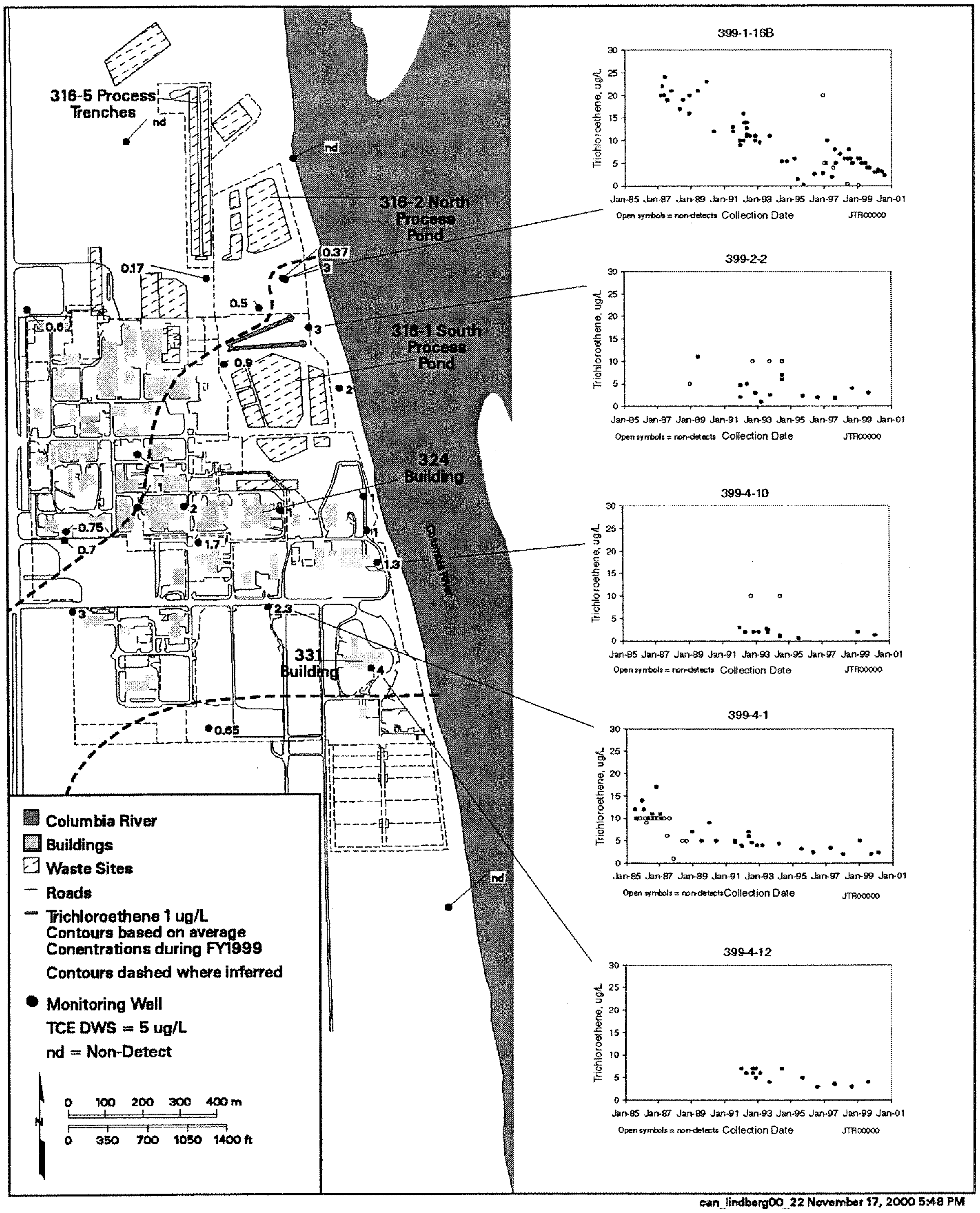
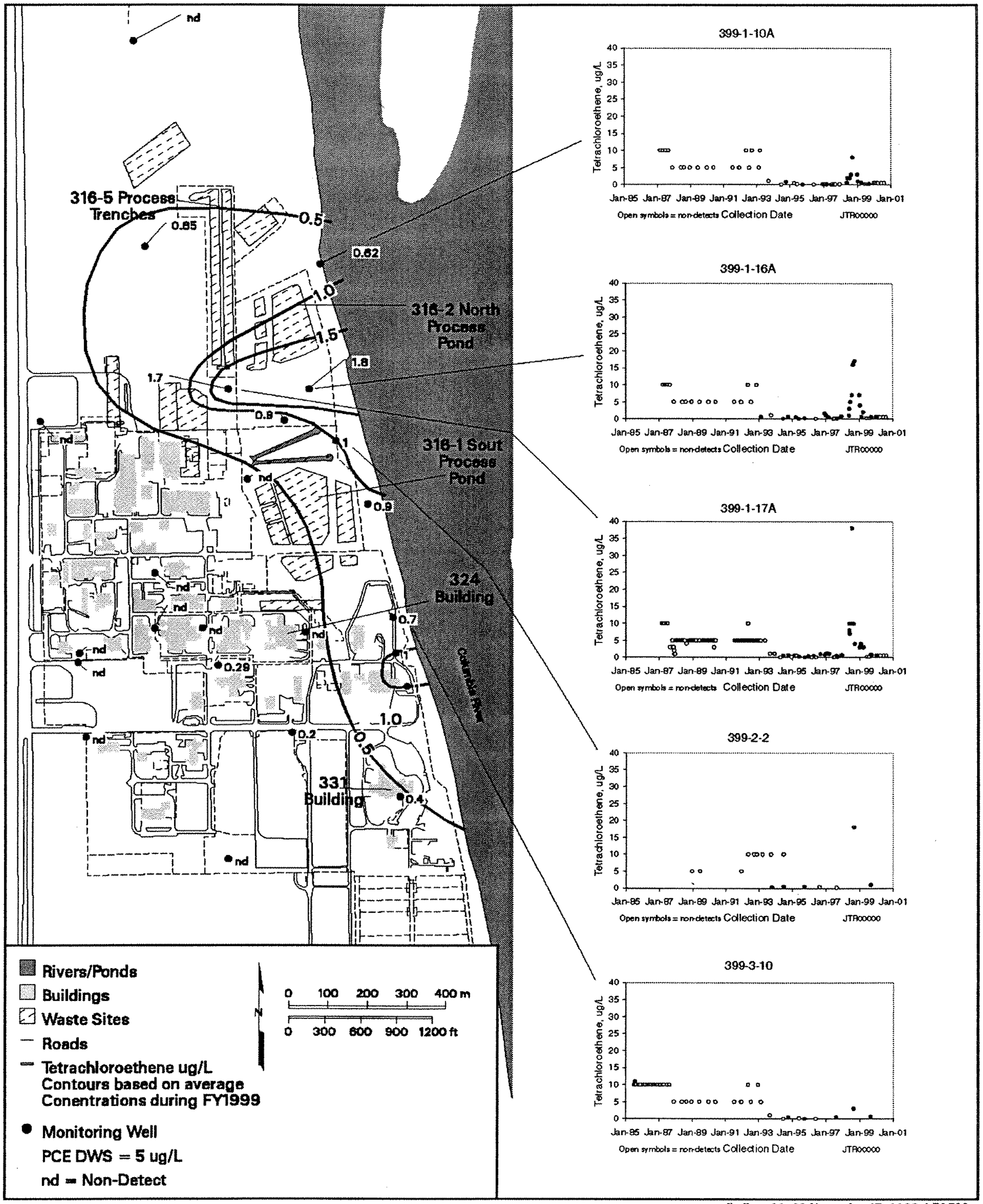
300 Area TCE Concentrations



300 Area PCE Concentrations



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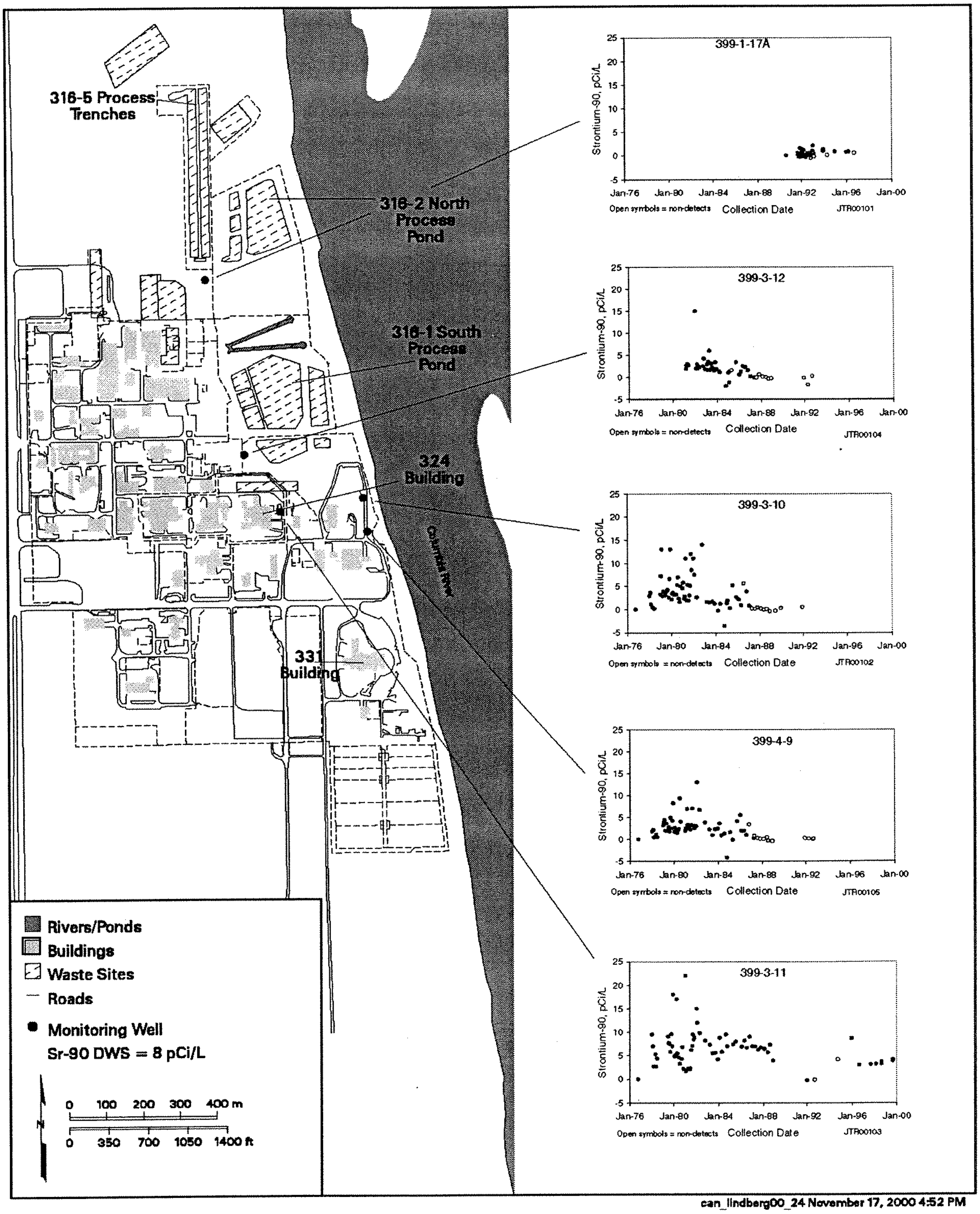
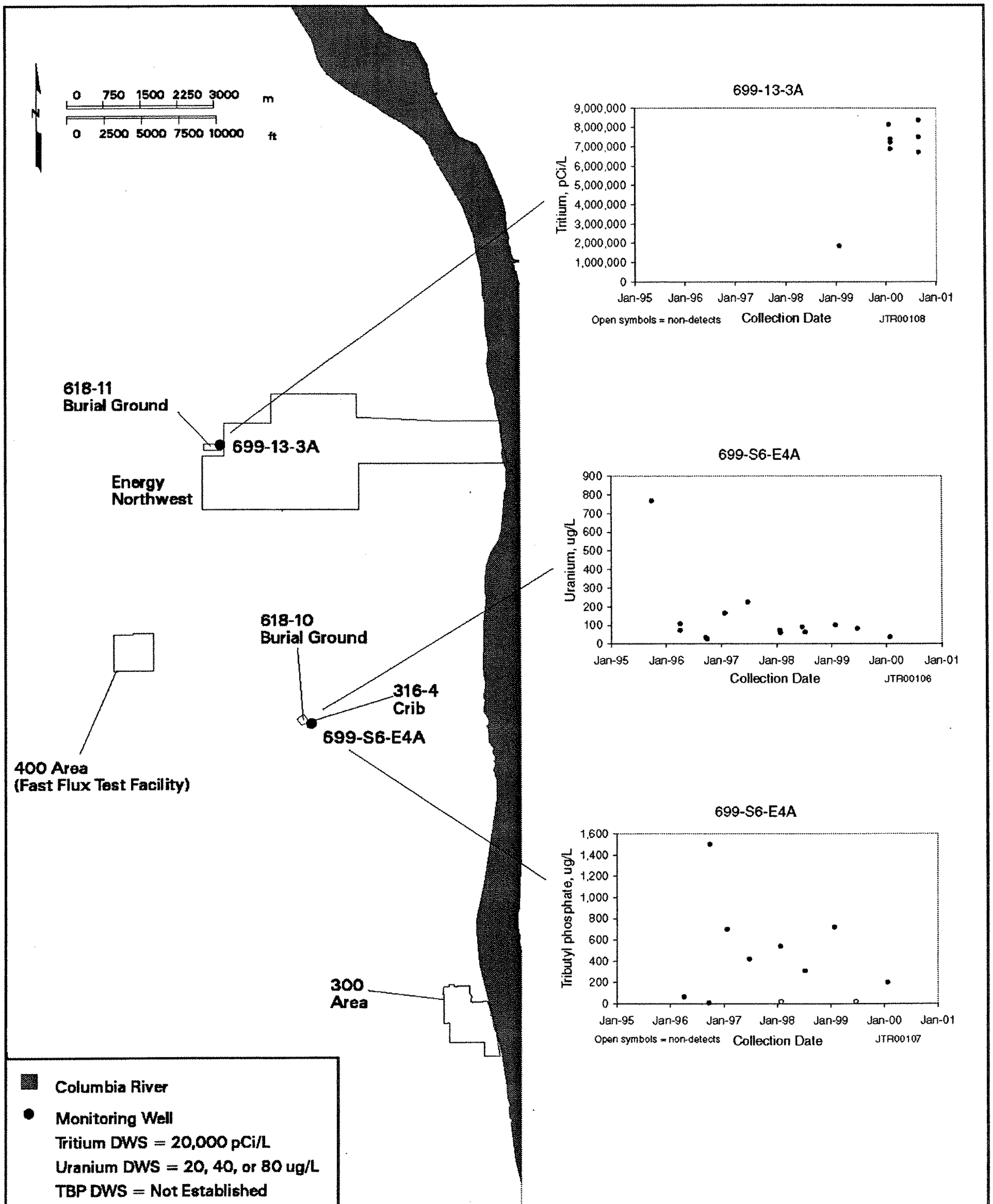
300 Area Sr-90 Concentrations



can_lindberg00_24 November 17, 2000 4:52 PM

Chemicals at 618-11 & 316-4



can_lindberg00_25 November 16, 2000 5:48 PM

APPENDIX D

LETTER AND EXCERPTS FROM 300 AREA PROCESS TRENCHES GROUNDWATER MONITORING PLAN (PNNL-13645)

093586

Job No. 22192
Written Response Required: NO
Due Date: N/A
Actionee: N/A
Closes CCN: N/A
OU: 300-FF-1
TSD: D-3-1, Operating Record
ERA: 300A APT
Subject Code: 6450, 8220, 5830

NOV 28 2001

U.S. Department of Energy
Richland Operations Office
J. B. Hebdon, Director
Regulatory Compliance and Analysis Division
P.O. Box 550, MSIN A5-58
Richland, Washington 99352

Subject: Contract No. DE-AC06-93RL12367
TEMPORARY AUTHORIZATION REQUEST FOR GROUNDWATER MONITORING AT THE 300 AREA PROCESS TRENCHES

Dear Mr. Hebdon:

The U.S. Department of Energy, Richland Operations Office (RL) has received approval from the Washington State Department of Ecology (Ecology) to revise the groundwater monitoring strategy at the 300 Area Process Trenches (trenches). The trenches are a final status unit undergoing postclosure care in accordance with the Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit. A new monitoring plan (PNNL-13645) has been developed to incorporate the strategy approved by Ecology, but RL needs Ecology approval to modify the permit prior to implementing the new monitoring plan. The new strategy adds sampling at five wells to enhance the area to be monitored down gradient of the trenches, eliminates sampling at two background wells, and incorporates a statistical approach that will better determine whether the concentrations of the constituents of concern are decreasing. In accordance with Washington Administrative Code (WAC) 173-303-830, Appendix I, these changes require a Class 2 modification. Rather than delay implementation of the new strategy for close to a year, Bechtel Hanford, Inc. proposes that a temporary authorization request be submitted to Ecology to allow the new monitoring plan to be implemented at once.

The temporary authorization request has been developed in accordance with WAC 173-303-830(4)(e)(ii)(B). During a meeting held on November 15, 2001, Ecology agreed to RL's approach for requesting a temporary authorization. WAC 173-303-830(4)(e)(ii)(C) requires that a public notice be issued within seven days before or after the date of submission of the modification request. In order to meet this requirement, the request has been included in the Hanford Update that will be issued in early December. Therefore, Ecology should receive the temporary authorization request by December 10, 2001.

BECHTEL HANFORD, INC.
3350 George Washington Way
Richland, WA 99352
tel (509) 375-4640
fax (509) 375-4644

J. B. Hebdon
Page 2

093586

NOV 28 2001

A suggested letter is attached for RL's use in requesting a temporary authorization to implement the new monitoring plan for the trenches. Copies of PNNL-13645 were provided to Ms. Gloria Williams for transmittal with the request. If you have any questions or need further information, please feel free to contact Ms. Donna Yasek on 372-9331.

Sincerely,

T. E. Logan
Vice President, Operations

DMY:lad

Attachment(s): Temporary Authorization Request

cc:
C. E. Clark (RL) A5-15, w/a
M. J. Furman (RL) A5-13, w/a
J. W. Lindberg (PNNL) K6-81, w/a
S. P. Luttrell (PNNL) K6-96, w/a
M. S. McCormick (RL) H0-12, w/a
K. M. Thompson (RL) A5-13, w/a
S. A. Thompson (FH) N1-25, w/a
G. A. Williams (RL) A5-15, w/a

J. B. Hebdon
Page 3

093586

NOV 28 2001

bcc:

J. V. Borghese H0-19, w/a
L. R. Curry H0-19, w/o
K. R. Fecht H0-02, w/o
R. S. Hanash H0-13, w/o
C. J. Kemp H0-19, w/a
R. J. Landon H0-02, w/o
T. E. Logan H0-14, w/a
G. B. Mitchem H0-19, w/o
D. M. Yasek H0-02, w/a
RS Letterbook H0-02, w/a
Document and Info Services H0-09

CONCURRENCES

DATE	11/21/01	11/21/01	RSH 11/26	11-26-01	11/26/01	11/26/01
INITIALS	JVB	LRC	RSH	CJK	RJL	GBM

0093586

Mr. Michael A. Wilson, Program Manager
Nuclear Waste Program
State of Washington
Department of Ecology
P.O. Box 47600
Olympia, Washington 98504

Dear Mr. Wilson:

HANFORD FACILITY RESOURCE CONSERVATION AND RECOVERY ACT (RCRA) PERMIT MODIFICATION AND REQUEST FOR TEMPORARY AUTHORIZATION FOR POSTCLOSURE MONITORING AT THE 300 AREA PROCESS TRENCHES

The U.S. Department of Energy, Richland Operations Office (RL) is requesting a permit modification in accordance with Washington Administrative Code (WAC) 173-303-830. The permit modification request includes changes determined to be a Class 2 modification. RL is requesting the State of Washington Department of Ecology (Ecology) grant a temporary authorization to implement these changes for a period of 180 days as specified in WAC 173-303-830(4)(e). The permit modification request is expected to be processed in the next modification cycle of the Hanford Facility RCRA Permit (HF RCRA Permit), Dangerous Waste (DW) Portion (ID# WA7890008967).

The documentation changes associated with the permit modification and temporary authorization reflect revisions being made to the RCRA groundwater monitoring program for the 300 Area Process Trenches (Part VI, Chapter 1). The attached Groundwater Monitoring Plan for the 300 Area Process Trenches (PNNL-13645) (Enclosure 1) has been revised to incorporate changes to the groundwater monitoring network, to introduce a statistical approach for calculating control limits, and to implement the corrective action monitoring plan for the unit.

In accordance with WAC 173-303-830(4)(e)(ii)(B), a temporary authorization request must include: (I) A description of the activities to be conducted under the temporary authorization; (II) An explanation of why the temporary authorization is necessary; and (III) Sufficient information to ensure compliance with the standards in WAC 173-303-280 through 173-303-395 and 173-303-600 through 173-303-680. Under a temporary authorization, DOE would implement PNNL-13645 by adding five wells to enhance the area to be monitored down gradient of the process trenches; and eliminating groundwater

093586

sampling at two background wells. Additionally, the new statistical approach would be implemented, with the objective of determining whether the concentrations of the constituents of concern are decreasing with time as expected in the 300-FF-5 Record of Decision. This approach has been approved by Dr. Goswami of your staff (see Enclosure 2, letter dated May 7, 2001). By granting a temporary authorization, Ecology will allow DOE to implement PNNL-13645. This temporary authorization would not affect the 300 Area Process Trenches compliance with the standards in WAC 173-303-280 through 173-303-395 and 173-303-600 through 173-303-680. The trenches are undergoing postclosure monitoring, and will maintain compliance with the enforceable portions of the 300 Area Process Trenches Modified Closure Plan, DOE/RL-93-73.

To request a temporary authorization, RL is required by WAC 173-303-830(4)(e)(ii)(C) to send a notice addressing the temporary authorization request to all persons on the facility mailing list. Enclosure 3 contains language RL has included in the December publication of the "Hanford Update" to satisfy the notice requirement. Enclosure 4 contains the signed permit modification form.

RL requests that Ecology review the enclosed information. If Ecology determines that the request is acceptable, please respond with a letter granting the temporary authorization. Should you have any questions about the documentation changes, please contact Gloria Williams of my staff, on (509) 372-0586 or Marvin Furman on (509) 373-9630.

Sincerely,

Joel B. Hebdon, Director
Regulatory Compliance Analysis Division

Enclosures:
1. Groundwater Monitoring Plan for the 300 Area Process Trenches (PNNL-13645)
2. Letter from Dr. Goswami, Ecology, to Mr. Furman, RL, dated May 7, 2001.
3. Text to Satisfy Public Notice Requirement
4. Proposed Permit Modifications and Updated Documentation

cc w/encls:
Ecology Library, Kennewick
R. J. Landon, BHI
Environmental Portal, FH
J. Price, Ecology
J. V. Borghese, BHI
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Tribes
S. P. Luttrell, PNNL
M. Goldstein, EPA

bcc: M. J. Furman,
G. A. Williams,
K. M. Thompson,

093586

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
1315 W. 4th Avenue • Kennewick, Washington 99336-6018 • (509) 735-7581

May 7, 2001

Mr. Marvin Furman
U.S. Department of Energy
Richland Operations Office
P.O. Box 550, MSIN A5-13
Richland, Washington 99352

Dear Mr. Furman:

Re: Statistical Assessment for the 300 Area Resource Conservation and Recovery Act of 1976 (RCRA) Ground Water Monitoring Plan

The Washington State Department of Ecology (Ecology) has evaluated the proposal presented by the United States Department of Energy (USDOE) requesting "variance" from applying interim status regulations at B-Pond and other Treatment, Storage, and Disposal (TSD) units, and their request to apply the Shewhart-CUSUM control limits for the 300 Area Process Trenches (APT). The purpose of this letter is to present regulatory guidance regarding the proposed "variance" from applying interim status regulations and to denote the requirements for achieving acceptable control limits for the 300 APT. This letter does not negate the current status of the site, but allows for variance.

B-Pond - "Variance" from applying interim status regulations. The following guidance is provided to the USDOE regarding the request for "variance" from applying interim status regulations for the RCRA monitoring network at B Pond monitored under interim indicator evaluation status. The appropriate indicators of ground-water contamination and statistical evaluation methods will be proposed by Pacific Northwest National Laboratory (PNNL) and submitted for approval by Ecology on a case-by-case basis.

The following criteria must be met prior to receiving approval of a variance from applying interim status regulations.

1. Identification of appropriate indicators of ground-water contamination and suitable statistical evaluation methods will be achieved by utilizing best professional judgement (i.e., waste source terms, conceptual models), expertise, and site-specific knowledge to: (a) determine the best technical approach based on hydrogeology and (b) tailor statistical approach to each individual site as necessary (i.e., consider type of monitoring, the nature of the data, the proportions of non-detects, spatial and temporal variations in the selection of appropriate statistical methods). A list of the appropriate indicators will be provided to Ecology for approval prior to implementation of the proposed plan.

Mr. Marvin Furman
May 7, 2001
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2. The selection of quality background data and data sets for identification of an appropriate baseline period. Once baseline data has been obtained, outliers will be properly addressed to avoid substantial bias in the statistical analysis.

3. American Society for Testing and Materials (ASTM) guidance will be utilized for circumstances regarding non-detects and outliers.

4. The utilization of probability plots in order to maintain normal distribution of data.

5. Input parameter values (e.g., k, h, and SCL) will be proposed and submitted to Ecology for approval prior to implementation of this plan.

6. Variance from applying interim status requirements for the RCRA monitoring network at B Pond and other TSD units currently monitored under interim indicator evaluation status will be allowed for a period to cover four sampling events. Upon completion of the four sampling events and statistical evaluation of the data, the submitted proposal shall be reevaluated by Ecology for subsequent approval.

300 Area Process Trenches (300-APT) – Calculation of control limits. The following table depicts the control limits and special conditions to be applied for each constituent of concern at the 300-APT as proposed in the USDOE/Ecology meeting held December 11, 2000.

Table 1. Summary of Various Control Limits at the 300 APT

Constituent of Concern	Shewhart CUSUM Parameter Value	Control Limit (µg/L)
	Well # 3-1-16A	
cis-DCE (µg/L)	4.5	0.803
TCE (µg/L)	4.5	1.72
	Well # 3-1-16B	
cis-DCE (µg/L)	4.5	[39, 262][b]
TCE (µg/L)	NA	5
	Well # 3-1-17A	
Uranium (µg/L)	4[a]	[7, 218]
	Well # 3-1-17B	
Uranium (µg/L)	4.5	0.67

[a] Use 4 sigma because there are 16 data points in the baseline period (ASTM 1996).
[b] Numbers in brackets indicate upper and lower limits.

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Specific procedures to be used are as follows:

1. For wells where the Maximum Contamination Level (MCL) has been and still is exceeded, quarterly monitoring will be conducted. One sample will be collected from each well during each sampling event and compared to the agreed upon control limits for each identified constituent of concern (i.e., cis-DCE, TCE, and uranium). If a control limit is exceeded (proof by verification sampling), a notification process will be followed.

2. For wells where the MCL has not been exceeded, semiannual monitoring will be conducted. One sample will be collected from each well during each sampling event and compared to the agreed upon control limits for each identified constituent of concern (i.e., cis-DCE, TCE, and uranium). A notification process will be followed after a confirmed exceedance (by verification sampling).

3. Currently tetrachloroethene (PCE) is not detected in the 300 APT wells. However, it has been detected in the past. PNNL will continue to monitor PCE and report detected results.

The proposed statistical approach shall be in effect for a period of two years or four sampling events. Based on the results of this trial application, Ecology would decide whether to continue, modify, or abandon the proposed approach in these facilities or to apply the approach to other facilities. The USDOE is therefore requested not to apply this variance or similar procedures/methods at other facilities with out Ecology's prior approval.

If further discussion is necessary, please contact Deborah Singleton at (509) 736-5722 or me at (509) 736-3015.

Sincerely,

Dib Goswami, PhD
Nuclear Waste Program

DG:lkd

cc: Doug Hildebrand, USDOE
John Morse, USDOE
Charissa Chou, PNL
Stuart Luttrell, PNL

0 9 3 5 8 6

Text to Satisfy Public Notice Requirement

The following is proposed to appear in the next publication of the "Hanford Update" to satisfy the notice requirement of Washington Administrative Code 173-303-830(4)(e)(ii)(C).

USDOE Requests Resource Conservation and Recovery Act Permit Modification

The U. S. Department of Energy (USDOE) has requested the State of Washington Department of Ecology (Ecology) grant a temporary authorization in accordance with Washington Administrative Code, Chapter 173-303-830(4)(e) for a Class 2 permit modification. The temporary authorization will allow USDOE to enhance the monitoring network surrounding the 300 Area Process Trenches.

The 300 Area Process Trenches are a final status unit under the Hanford Facility Resource Conservation and Recovery Act Permit (Part VI, Chapter 1). The unit has been closed in accordance with the 300 Area Process Trenches Modified Closure Plan, DOE/RL-93-73, and is currently undergoing post-closure monitoring. The Groundwater Monitoring Plan for the 300 Area Process Trenches, PNNL-13645 has been issued to add five wells to enhance the area to be monitored down gradient of the process trenches, and eliminate groundwater sampling at background wells. Additionally, the new plan incorporates a statistical approach that would be implemented to better determine whether the concentrations of the constituents of concern are decreasing with time, as was expected in the 300-FF-5 Record of Decision

Ecology plans on evaluating USDOE's request. If Ecology finds the request acceptable, Ecology will grant the temporary authorization and incorporate the modification into the Hanford Facility Resource Conservation and Recovery Act Permit during the next modification cycle. If you have any questions, please contact Mr. John Price Ecology at (509) 736-3029, or Ms. Gloria Williams, USDOE, at (509) 372-0586.

0 9 3 5 8 6

Hanford Facility RCRA Permit Modification Notification Forms
for
300 Area Process Trenches
Part VI, Chapter 1

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Hanford Facility RCRA Permit Modification Notification Form	
Unit: 300 Area Process Trenches	Permit Part & Chapter: Part VI, Chapter 1

Description of Modification:
Hanford Facility RCRA Permit, Section VI.1.A:

VI.1.A. COMPLIANCE WITH APPROVED MODIFIED CLOSURE PLAN

The Permittees shall comply with all requirements set forth in Attachment 31, including all Class 1 Modifications specified below , and Amendments specified in Condition VI.1.B. Enforceable portions of the plan are listed below. All subsections, figures, and tables included in these portions are also enforceable, unless otherwise stated. The Permittees shall also comply with all the requirements in the 300-FF-1 and 300-FF-5 Record of Decision and Addendum and the Ground Water Monitoring Plan (~~WHC-SD-EN-AP-185, Rev. 0A~~ PNNL-13645). The 300 Area Process Trenches achieved closure in May 1998 in accordance with the Closure Plan contained in Attachment 31, and Permit Conditions contained in this Chapter. Therefore, enforceable portions of the plan currently consist of those associated with post-closure care. These portions are Sections 8.2, 8.4, and 8.5.

Part A, Form 3, Permit Application, Revision 4, May 1995

Section ADD-1	Addendum, Introduction
Section 8.2.	Inspection Plan, from Class 1 Modification for quarter ending September 30, 1998
Section 8.4.	Maintenance Plan, from Class 1 Modification for quarter ending September 30, 1998
Section 8.5.	Personnel Training, from Class 1 Modification for quarter ending September 30, 1998

Modification Class:[1 2 3]	Class 1	Class [1]1	Class 2	Class 3
Please check one of the Classes:			X	

Relevant WAC 173-303-830, Appendix I Modification: C.1.a

Enter wording of the modification from WAC 173-303-830, Appendix I citation:

C. Ground Water Protection
  1. Changes to wells
     a. Changes in the number, location, depth, or design or upgradient or downgradient wells of permitted groundwater monitoring system

Submitted by Co-Operator:		Reviewed by RL Program Office:		Reviewed by Ecology:		Reviewed by Ecology:	
T. E. Logan	Date 11/21/01	M. S. McCormick	Date	J. B. Price	Date	L. E. Ruud	Date

[1] Class 1 modifications requiring prior Agency approval.

[2] This is only an advanced notification of an intended Class [1]1, 2, or 3 modification, this should be followed with a formal modification request, and consequently implement the required Public Involvement processes when required.

[3] If the proposed modification does not match any modification listed in WAC 173-303-830 Appendix I, then the proposed modification should automatically be given a Class 3 status. This status may be maintained by the Department of Ecology, or down graded to [1]1, if appropriate.

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Hanford Facility RCRA Permit Modification Notification Form	
Unit: 300 Area Process Trenches	Permit Part & Chapter: Part VI, Chapter 1

Description of Modification:
Hanford Facility RCRA Permit, Section VI.1.B:

VI.1.B. AMENDMENTS TO THE APPROVED MODIFIED CLOSURE PLAN

VI.1.B.b. Pursuant to Condition II.K.7. of the Hanford Facility Wide Permit, the 300 Area Process Trenches (APT) closure shall be a Modified Closure in coordination with the Record of Decision (ROD) for 300-FF-1 and 300-FF-5. Sections of CERCLA documents (examples may include, but are not limited to, Remedial Design/Remedial Action CERCLA work plan, the Operation and Monitoring Work Plan, etc.), which satisfy requirements and Conditions of this Modified Closure Plan, will be reviewed and approved by Ecology.

VI.1.B.i. As stipulated through the RCRA Final Status Compliance Monitoring Plan (i.e., ~~WHC-SD-EN-AP-185~~ PNNL-13645) Appendix IX, sampling shall not be required unless post-closure monitoring results indicate a need to do so.

VI.1.B.q. Page 8-3, line 20. Well condition will be assessed pursuant to Condition II.F. of the Permit.

VI.1.B.r. Page 8-5, Section 8.5. This section will reference Section II.C. of the Permit for additional training requirements.

Modification Class: [1 2 3]	Class 1	Class [1]1	Class 2	Class 3
Please check one of the Classes:			X	

Relevant WAC 173-303-830, Appendix I Modification: C.1.a

Enter wording of the modification from WAC 173-303-830, Appendix I citation:

C. Ground Water Protection
1. Changes to wells
   a. Changes in the number, location, depth, or design or upgradient or downgradient wells of permitted groundwater monitoring system

Submitted by Co-Operator:		Reviewed by RL Program Office:		Reviewed by Ecology:		Reviewed by Ecology:	
T. E. Hogan	11/21/01 Date	M. S. McCormick	Date	J. B. Price	Date	L. E. Ruud	Date

[1] Class 1 modifications requiring prior Agency approval.

[2] This is only an advanced notification of an intended Class [1]1, 2, or 3 modification, this should be followed with a formal modification request, and consequently implement the required Public Involvement processes when required.

[3] If the proposed modification does not match any modification listed in WAC 173-303-830 Appendix I, then the proposed modification should automatically be given a Class 3 status. This status may be maintained by the Department of Ecology, or down graded to [1]1, if appropriate.

PNNL-13645

300 Area Process Trenches Groundwater Monitoring Plan

J. W. Lindberg
C. J. Chou

August 2001

Prepared for
the U.S. Department of Energy
under Contract DE-AC06-76RL01830

Pacific Northwest National Laboratory
Richland, Washington 99352

Summary

The 300 Area process trenches, also designated 316-5 process trenches, were operated to receive effluent containing dangerous wastes from nuclear research and fuel fabrication laboratories in the 300 Area between 1975 and 1994. They are regulated as a treatment, storage, or disposal facility under the *Resource Conservation and Recovery Act of 1976* (RCRA) and are within the 300-FF-5 Operable Unit regulated under the *Comprehensive Environmental Response, Compensation, and Recovery Act of 1980* (CERCLA). Currently, the trenches are included in the Hanford Site RCRA Dangerous Waste Permit, have an approved closure/post-closure plan, and are regulated under a RCRA final-status, corrective action groundwater monitoring program (WAC 173-303-645, and by reference 40 CFR 264). They are also in a CERCLA remedial action process under a record of decision allowing natural attenuation as a groundwater cleanup remedy.

The objective of groundwater monitoring during the corrective-action period is to monitor the trend of the constituents of concern to confirm that they are attenuating naturally, as expected by the CERCLA record of decision for the 300-FF-5 Operable Unit. In addition, the corrective-action groundwater monitoring program must be at least as effective as the previous compliance monitoring program in determining compliance with groundwater protection standards.

The existing groundwater monitoring plan (Lindberg et al. 1995) is being replaced by this document. This monitoring plan includes well and constituent lists; summarizes sampling, analytical, and quality control requirements; and incorporates all the interim changes made since the last revision of the groundwater monitoring plan for the 300 Area process trenches. Changes from the previous monitoring plan include updating the discussion on hydrogeology and conceptual model, redesigning the monitoring well network to include 11 wells rather than the previous eight, and adopting a control chart statistical approach that will track the contamination trends better than the previous plan with reduced costs.

Analytes to be tested in groundwater samples from network wells are uranium, cis-1,2-dichloroethene, trichloroethene, and tetrachloroethene. Uranium and cis-1,2-dichloroethene remain above drinking water standards in wells of the network, trichloroethene continues to be detected in network wells but there is an additional source offsite, and tetrachloroethene is no longer detected in the network wells, but exceeded the drinking water standard as recently as 1998.

Contents

Figures

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6.0 Groundwater Monitoring Program

Concentration limits (in this case, drinking water standards or EPA-proposed drinking water standards) for two of the constituents of interest (cis-DCE and uranium) have been, and still are, exceeded in some downgradient wells at the 300 Area process trenches. Therefore, a plan for corrective action groundwater monitoring is required.

6.1 Objectives

In accordance with WAC-173-303-645(11)(d), the groundwater monitoring program must demonstrate the effectiveness of the corrective action and must be at least as effective as a compliance monitoring program in determining compliance with the groundwater protection standards. The compliance monitoring program must, in turn, provide for a sufficient number of samples (a sequence of at least four samples collected at least semiannually, unless an alternative sampling procedure has been approved in accordance with WAC 173-303-645[8][g][ii]). Additionally, a compliance monitoring program should use one of four specified statistical methods (including control charts), unless an alternative method has been approved by Ecology in accordance with WAC 173-303-645(8)(h)(iv).

This corrective action program proposes to use both an alternative sampling procedure and a revised statistical method (see Section 7.3) to satisfy the corrective action groundwater monitoring requirements. These alternative approaches will improve the ability of the monitoring program to monitor for trends and to detect impacts to groundwater quality while achieving significant savings by reducing the number of routine groundwater samples required for statistical testing purposes. The proposed alternate corrective action program will

1. meet the needs of final status compliance monitoring
2. provide for an efficient sampling plan that relies on only one groundwater sample per well per sampling period.

6.2 Special Conditions

There are two conditions that are of special concern to the development of this groundwater monitoring plan. The first concern is related to the depth in the aquifer of the residual contamination. Uranium and the contaminants from upgradient sources are in the upper part of the unconfined aquifer. Therefore, they need to be monitored by wells that are screened at the water table (the "A" wells). Volatile organic compounds such as cis-DCE and TCE are found in higher concentrations at the bottom of the unconfined aquifer (the "B" wells), and, thus, need to be monitored by wells screened at the bottom of the aquifer. Therefore, the monitoring well network needs to be a combination of "A" and "B" wells.

The second special condition is the relationship of the water table to fluctuations in Columbia River stage. How quickly river stage fluctuates and the magnitude of the fluctuations determines the water table gradient and overall elevation of the water table. In turn, the water-table gradient influences the direction and rate of groundwater flow beneath the 300 Area process trenches. The overall elevation of the water table determines whether the lower vadose zone becomes temporarily saturated, mobilizing waste constituents stored in the vadose zone. Selection of wells for the monitoring network must consider the variability in groundwater flow direction and rate due to the river fluctuations. Furthermore, the sampling schedule must be consistent with high and low stages of the river in order to test the full variability of contaminant concentration as it is affected by river stage.

6.3 Monitoring Well Network

The 11 downgradient wells of the proposed monitoring well network (Figure 6.1) are located downgradient of the 300 Area process trenches in an eastward to southward direction. (Upgradient wells are no longer needed to support the objectives of this groundwater monitoring plan.) The network includes all the available wells in this arc that meet the requirements of WAC 173-160 for resource protection wells and are within 300 meters of the 300 Area process trenches. The location of these wells is designed to intercept existing or potentially new plumes originating at the trenches during low to high stages of the Columbia River. Wells that do not meet WAC 173-160 requirements are not included in the network in order to avoid making decisions on the effectiveness of the corrective action by the use of data from wells that do not meet the minimum requirements of WAC 173-160.

The six wells monitoring the upper portion of the uppermost aquifer (the unconfined aquifer) include

399-1-7	399-1-11	399-1-17A
399-1-10A	399-1-16A	399-1-21A

With the exception of well 399-1-11, each of the wells listed above has a corresponding deeper well screened in the lower portion of the unconfined aquifer. The deeper wells include

399-1-8 (near 399-1-7)	399-1-16B	399-1-21B
399-1-10B	399-1-17B	

Appendix C contains construction details of the proposed wells.

In addition to using "A" and "B" wells (bottom and top of aquifer) to differentiate groundwater contamination in the lower versus upper portions of the unconfined aquifer, further discrimination of contaminant stratification can be tested with the Spider sampler. This tool will be used on a limited basis in a few wells (e.g., 399-1-16B) to determine the vertical profile for contaminants across the screened interval. At well 399-1-16B, screened at the bottom of the unconfined aquifer, the tool will be used to determine if the contamination is localized at the base of the aquifer (due to volatile organic compounds as dense non-aqueous phase liquids) or more dilute over a larger portion of the screened interval.

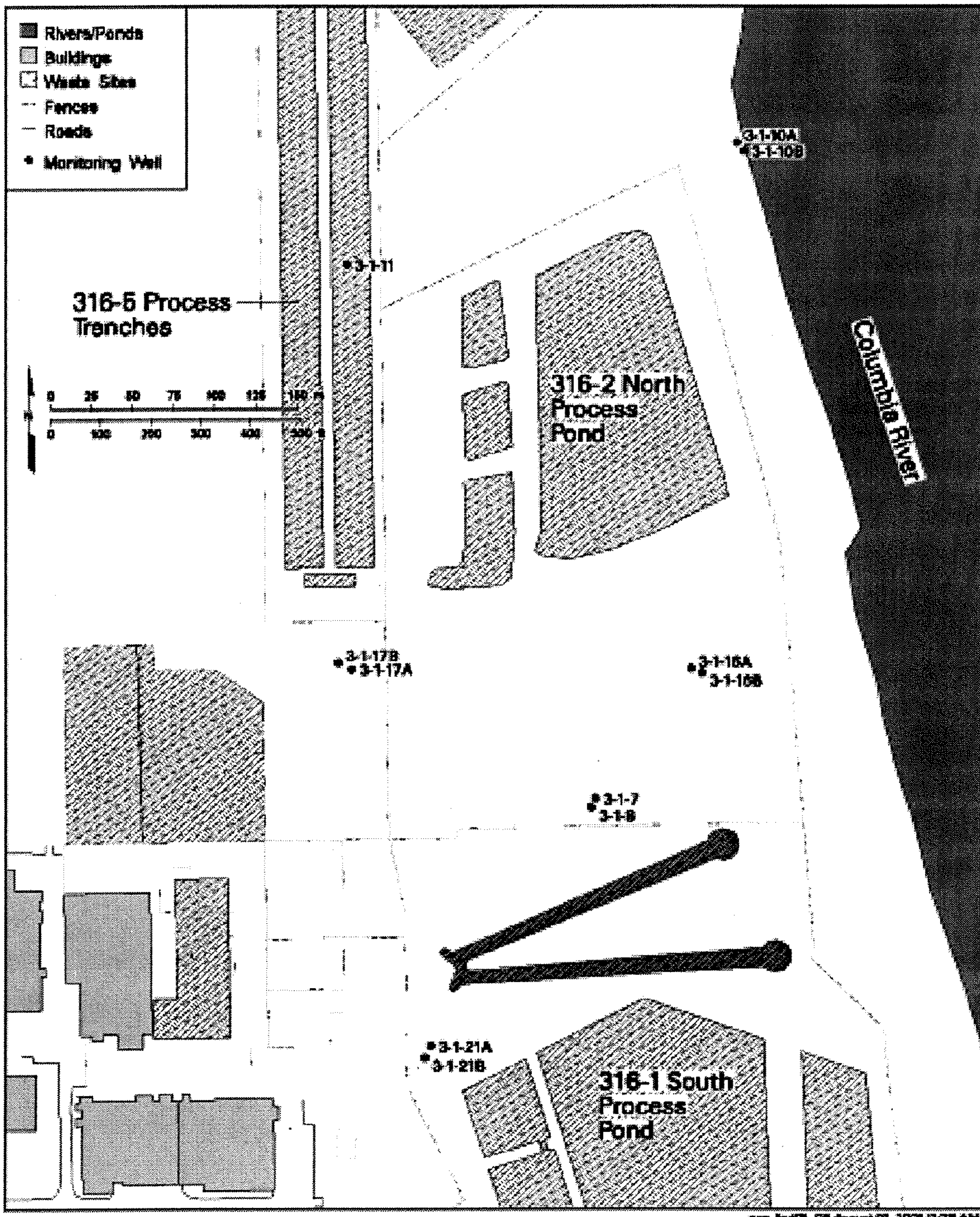

Figure 6.1. Location of Wells in the Proposed Well Network

6.3

6.4 Constituent List and Sampling Frequency

As discussed in Section 4.4.3 the constituents of concern that remain above the groundwater quality criteria are uranium and cis-DCE. (Note: The maximum contaminant levels are the groundwater quality criteria at this site.) These two constituents constitute the main constituent list. TCE and PCE no longer exceed the maximum contaminant levels, but remain as contaminants of concern because of their exceedances in recent years and potential to reappear.

Tritium from one or more upgradient sources to the northwest and nitrate from offsite sources to the southwest (Hartman et al. 2001) are not included as contaminants of concern for the 300 Area process trenches and will not be monitored for RCRA objectives by this groundwater monitoring program. However, they will be monitored by the Hanford Groundwater Monitoring Project for the *Atomic Energy Act of 1954*.

While analyzing groundwater samples from the 300 Area process trenches for cis-DCE, TCE, and PCE, other volatile organic compounds are included also because of the nature of the volatile organic analysis (8260_VOA_GCMS – Gas Chromatograph/Mass Spectroscopy). Therefore, other volatile organic compounds such as 1,2-dichloroethane, 1,1,1-trichloroethane, acetone, benzene, carbon tetrachloride, and many others are included also. This will provide confidence that additional volatile organic compounds are not escaping detection by this groundwater monitoring program.

Sampling frequency will depend on the recent history for each groundwater analyte at each network well. A guidance letter from the regulator (Ecology 2001) requires that at wells where the contaminant of concern exceeds the groundwater quality criteria (i.e., maximum contaminant level) the sampling frequency shall be quarterly. In wells where the concentration of constituents of concern is less than the groundwater quality criteria the sampling frequency shall be semiannually (see Section 7.3). Table 6.1 provides the details about whether the contaminants of concern are currently exceeding the groundwater quality criteria and the resulting sampling frequency for each well of the proposed network.

In addition to the contaminants of concern mentioned above, groundwater samples will occasionally be tested on a limited basis in a few selected wells for ICP metals, anions, and alkalinity. The purpose of these additional tests is to characterize the groundwater for parameters that may affect the amount and rates of adsorption or leaching of uranium.

6.5 Groundwater Parameter Analyses and Method Detection Limit

Table 6.2 lists the groundwater analysis method detection limits currently in use for groundwater parameters required in Section 6.3.2, as well as the groundwater quality criteria of this groundwater monitoring program. Uranium will be analyzed as total chemical uranium by one of two methods, either kinetic phosphorescence or laser induced phosphorimetry. The volatile organic compounds will be analyzed by method SW-846 8260 gas chromatography/mass spectroscopy.

Table 6.1. Well Sampling Frequency Based on Current Concentration Levels of Contaminants of Concern in Network Monitoring Wells

Well	Uranium	Cis-DCE	TCE	PCE	
GWQC	20 μg/L[(a)]	70 μg/L[(a)]	5 μg/L[(a)]	5 μg/L[(a)]	Frequency[(d)]
399-1-7	Y[(b)]	N[(c)]	N	N	Quarterly
399-1-8	N	N	N	N	Semiannual
399-1-10A	Y	N	N	N	Quarterly
399-1-10B	N	N	N	N	Semiannual
399-1-11	Y	N	N	N	Quarterly
399-1-16A	Y	N	N	N	Quarterly
399-1-16B	N	Y	N	N	Quarterly
399-1-17A	Y	N	N	N	Quarterly
399-1-17B	N	N	N	N	Semiannual
399-1-21A	N	N	N	N	Semiannual
399-1-21B	N	N	N	N	Semiannual

(a) Groundwater quality criteria (maximum contaminant levels at this site).
(b) Y = Yes, the groundwater quality criterion is exceeded.
(c) N = No, the groundwater quality criterion is not exceeded.
(d) Resultant frequency based on current concentration levels of contaminants of concern. The concentration levels may change in the future causing the sampling frequencies to change appropriately.

Table 6.2. Groundwater Quality Criteria for the 300 Area Process Trenches Groundwater Waste Parameters (Constituents of Concern) and Associated Method Detection Limits

Groundwater Contaminant	GWQC[(a)] (MCL)	MDL[(b)]
Uranium	20 μg/L	0.1 μg/L
Cis-1,2-Dichloroethene	70 μg/L	0.5 μg/L
Trichloroethene	5 μg/L	0.31 μg/L
Tetrachloroethene	5 μg/L	0.36 μg/L

(a) Groundwater quality criteria are federal drinking water standards and maximum contaminant levels.
(b) Method detection level.

6.6 Determination of Groundwater Flow

Depth to water measurements will continue to be collected from each monitoring well when each is sampled. In addition, a complete list of wells sampled for this plan, for the *Atomic Energy Act of 1954*, and for the CERCLA 300-FF-5 Operable Unit Operations and Maintenance Plan will be measured annually in March to provide a detailed water-table map. The water-table maps, in turn, will provide the information necessary to estimate groundwater flow direction by "contouring" the water-table surface and

6.5

to estimate flow rate from the water-table gradient. Using the Darcy equation (1), the average flow rate of groundwater will be calculated from estimates of hydraulic conductivity, the water-table gradient, and effective porosity.

Another method of determining groundwater flow direction and flow rate is the use of a down-well flow meter. One type of flow meter currently being used at the Hanford Site uses a down-hole camera capable of viewing colloidal-size particles. The probe containing the down-hole camera is coupled to a magnetometer for orientation. The flow meter tracks the movement of the colloidal-size particles, and flow rate and direction of the particles are recorded and used to calculate groundwater flow rate and flow direction. This type of flow meter will be used at one or more of the wells in the 300 Area process trenches network. The flow meter also has continuous mode capabilities that make it useful for tracking the flow direction and rate of groundwater for extended periods (e.g., days or weeks). By applying this flow meter to wells near the river, the tool may provide a better understanding of the movement of water under the transitory conditions that exist in the zone of groundwater/river interaction. The data obtained can be used to refine and calibrate numerical models for groundwater and contaminant transport through this zone.

6.7 Sampling and Analysis Protocol

Groundwater monitoring at the 300 Area process trenches well network is part of the Hanford Groundwater Monitoring Project. Procedures for groundwater sampling, documentation, sample preservation, shipment, and chain-of-custody requirements are described in PNNL or subcontractor procedures manuals (ES-SSPM-001) and quality requirements are provided in the quality assurance plan[3]. Samples generally are collected after three casing volumes of water have been purged from the well or after field parameters (pH, temperature, specific conductance, and turbidity) have stabilized. For routine groundwater samples, preservatives are added to the collection bottles before their use in the field. Samples to be analyzed for metals are usually filtered in the field so that the results represent dissolved metals.

Procedures for field measurements are specified in the subcontractor's or manufacturer's manuals. Analytical methods are specified in contracts with laboratories, and most are standard methods from *Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods* (EPA 1986). Alternate procedures meet the guidelines of SW-846, Chapter 10. Analytical methods are described in Gillespie (1999).

6.8 Quality Assurance and Quality Control

The groundwater monitoring project's quality assurance/quality control (QA/QC) program is designed to assess and enhance the reliability and validity of groundwater data. The primary quantitative measures or parameters used to assess data quality are accuracy, precision, completeness, and the method detection limit. Qualitative measures include representativeness and compatibility. Goals for data representativeness for groundwater for groundwater monitoring projects are addressed qualitatively by the

[3] PNNL ETD-012, *Quality Assurance Plan*, Rev. 1. Hanford Groundwater Monitoring Project, Pacific Northwest National Laboratory, Richland, Washington.

specifications of well locations, well construction, sampling intervals, and sampling and analysis techniques in the groundwater monitoring plan for each facility. Comparability is the confidence with which one data set can be compared to another.

The QC parameters are evaluated through laboratory checks (e.g., matrix spikes, laboratory blanks), replicate sampling and analysis, analysis of blind standards and blanks, and interlaboratory comparisons. Acceptance criteria have been established for each of these parameters, based on guidance from EPA (1986). When a parameter is outside the criteria, corrective actions are taken to prevent a future occurrence and affected data are flagged in the database.

6.7

7.0 Data Management, Evaluation, and Reporting

This section describes how groundwater data are stored, retrieved, evaluated, and interpreted. Statistical evaluation methods and reporting requirements are also described.

7.1 Data Management

The contract laboratories report analytical results electronically. The results are loaded into the Hanford Environmental Information System (HEIS) database. Field-measured parameters are entered manually or through electronic transfer. Paper data reports and field records are considered to be the record copies and are stored at PNNL.

The data undergo a validation/verification process according to a documented procedure (Procedure QC-5, RCRA Groundwater Data Validation and Verification Process in PNL-MA-567 Manual) cited in the project QA plan[4]. QC data are evaluated against the criteria listed in the project QA plan and data flags are assigned when the data do not meet those criteria. In addition, data are screened by scientists familiar with the local hydrogeology, compared to historical trends or spatial patterns, and flagged if they are not representative. If necessary, the lab may be asked to check calculations or reanalyze the sample, or the well may be resampled.

7.2 Interpretation

After data are validated and verified, the data are used to interpret groundwater conditions at the site. Interpretive techniques include

- Hydrographs – graph water levels versus time to determine decreases, increases, seasonal, or manmade fluctuations in groundwater levels.
- Water-table maps – use water-table elevations from multiple wells to construct contour maps to estimate flow directions. Groundwater flow is assumed to be perpendicular to lines of equal potential.
- Flow meter – results provide highly localized measurements of groundwater flow directions and flow rates at the locations of wells where the tools are used.
- Spider sampler – allows collection of groundwater at discrete intervals within a monitoring well's screened portion thereby helping to characterize the vertical profile of groundwater contamination.

[4] PNNL ETD-012, *Quality Assurance Plan*, Rev. 1. Hanford Groundwater Monitoring Project, Pacific Northwest National Laboratory, Richland, Washington.

- Trend plots – graph concentrations of chemical or radiological constituents versus time to determine increases, decreases, and fluctuations. May be used in tandem with hydrographs and/or water-table maps to determine if concentrations relate to changes in water level or in groundwater flow directions.

- Plume maps – map distributions of chemical or radiological constituents areally in the aquifer to determine the source and extent of contamination. Changes in plume distribution over time aid in determine of movement of plumes and direction of flow.

- Contaminant ratios – can sometimes be used to distinguish between different sources of contamination.

7.3 Statistical Evaluation

This section describes the statistical evaluation methods, their objectives, and provides agreed upon control limits for the 300 Area process trenches specified in Ecology letter (2001). Some wells (i.e., 399-1-10A and 399-1-10B) and their respective control limits, however, are not provided in the letter to DOE from Ecology[5]. For these wells, control limits are established in this document following Ecology guidance. Statistical evaluations are not performed on some of the proposed network wells at the 300 Area process trenches (i.e., wells 399-1-7, 399-1-8, 399-1-11, 399-1-21A, and 399-1-21B) because of insufficient data (less than the minimum required eight baseline data points). Control limits for the constituents of concern (cis-DCE, TCE, and uranium) for these wells will be established as soon as sufficient baseline data become available.

7.3.1 Objectives of Statistical Evaluation

Concentration limits for the constituents of concern have been, and still are exceeded in some compliance wells at the 300 Area process trenches. Therefore, a plan for a corrective action groundwater monitoring program is required (WAC 173-303-645[2][a][iii]). The objective of the groundwater monitoring program at the trenches during the corrective action period is to demonstrate the effectiveness of the corrective action program (WAC 173-303-645[11][d]). Such a monitoring program must be as effective as the compliance monitoring program in determining compliance with the groundwater protection standards (WAC 173-303-645[11][d]). Accordingly, the objective of the statistical evaluation for the trenches is to monitor the trend of the contaminants of concern to confirm that natural attenuation is occurring as expected by the CERCLA record of decision for the 300-FF-5 Operable Unit. This is best achieved through the use of the combined Shewhart-CUSUM (cumulative sum) control chart approach as depicted in the next section.

[5] Letter from Dib Goswami (Washington State Department of Ecology, Olympia, Washington) to Marvin Furman (U.S. Department of Energy, Richland, Washington), *Statistical Assessment for the 300 Area Resource Conservation and Recovery Act of 1976 (RCRA) Ground Water Monitoring Plan*, dated May 7, 2001 (see Appendix D).

7.3.2 Rationale for Using Shewhart-CUSUM Control Chart Method

In accordance with WAC 173-303-645(8)(h), acceptable statistical methods include analysis of variance (ANOVA), tolerance intervals, prediction intervals, control charts, test of proportions, or other statistical methods approved by Ecology. The type of monitoring, the nature of the data, the proportions of non-detects, spatial and temporal variations are some of the important factors to be considered in the selection of appropriate statistical methods. One of the alternative statistical tests, allowable under final status regulations WAC 173-303-645(8)(h), is the use of a combined Shewhart-CUSUM control chart approach, first referenced by Westgard et al. (1977) and further developed by Lucas (1982). This method is also discussed in a groundwater context by Starks (1989), Gibbons (1994), and ASTM (1996) and first adopted into EPA guidance in 1989 (EPA 1989, 1992). Statisticians of Washington State University evaluated the efficacy of this method for monitoring groundwater quality on behalf of Ecology (WSU 1999). In their report, the university endorsed the control chart method of monitoring groundwater quality. There are several advantages in applying the control chart procedure:

- This method can be implemented with a single observation at any monitoring event (i.e., this method is efficient).
- This method could be applied to monitoring each well individually and yet maintain desired site-wide false positive and false-negative error rates. That is, this method is effective. The spatial variations that adversely affect the ANOVA procedure do not play a role under the control chart procedure. (Note: Due to the elimination of spatial variability, the uncertainty in measured concentrations is decreased making intra-well comparisons more sensitive to a real release [that is, false negatives] and false positive results [ASTM 1996]).
- The power of the control chart method could be enhanced by the combined Shewhart and CUSUM procedures. It is well known that the Shewhart procedure is sensitive to sudden shifts and the CUSUM procedure is sensitive to gradual changes in the mean concentrations. A combined Shewhart and CUSUM procedure, therefore, is well designed to detect both types of changes.

7.3.3 Shewhart-CUSUM Control Chart Procedures

The combined Shewhart–CUSUM method can be implemented following a baseline of eight or more independent sampling periods for a given well (ASTM 1996). The method assumes that the groundwater baseline data and future observations will be independent and normally distributed. The most important assumption is that the data are independent. The assumption of normality can usually be met by log-transforming the data or by other Box-Cox transformations. The method is more fully discussed in Lucas (1982), Starks (1989), Gibbons (1994), ASTM (1996), and Montgomery (1997).

The method is a sequential testing procedure to test for an upward shift in the mean concentration of a contaminant of concern. The Shewhart portion of the test checks for any sudden upward shift in ground-water quality parameters based on a single observation, while the CUSUM checks for any gradually

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increasing trend in the groundwater quality parameters. The procedure can be implemented as follows: Let x'_i be a series of independent baseline observations $i = 1, \ldots, b$ ($b = 8$). Let x_i be a series of future monitoring measurements $i = 1, 2, 3, \ldots$.

Then, using the baseline data, the following steps are applied:

1. Determine if the x'_i can be assumed to follow a normal distribution with mean μ and standard deviation σ. If not, transform the x'_i using the appropriate Box-Cox transformation and work with the transformed data.

2. Use the baseline data to compute the estimates $\overline{x}' = \sum_{i=1}^{b} x'_i/b$ for μ and $s' = \sqrt{\sum_{i=1}^{b}(x'_i - \overline{x}')^2/(b-1)}$ for σ.

3. Determine the upper Shewhart control limit (SCL) for the procedure by calculating $SCL = \overline{x}' + z_s s'$ where z_s is a percentile from the standard normal distribution used to set the false negative and false positive values of the Shewhart control limit. The value of z_s that is most often suggested for groundwater use is 4.5 by Lucas (1982), Starks (1989), EPA (1989), and ASTM (1996). Other values may also be used, depending on the sampling scheme used and whether verification sampling is used to modify the false positive and false negative error rates.

4. Determine the upper CUSUM control limit (CCL), with $CCL = \overline{x}' + z_c s'$. The value of z_c suggested by Lucas (1982), Starks (1988), and EPA (1989) is $z_c = 5$. This value can also be adjusted to reach desired false negative and false positive error rates. In practice setting $z_c = z_s = 4.5$ results in a single limits with no compromise in leak detection capabilities (ASTM 1996).

5. Determine the amount of increased shift in the mean of the water quality parameter of interest to detect an upward trend. This value is referenced as k and is usually measured in σ units of the water quality parameter. Lucas (1982), Starks (1988), and EPA (1989) suggest a value of $k = 1$ if there are less than 12 baseline observations; and a value of $k = 0.75$ if there are 12 or more baseline observations.

Using the monitoring data after the baseline measurements have been established:

6. Compute the CUSUM statistic as $S_i = \max\{0, (x_i - ks') + S_{i-1}s'\}$ as each new monitoring measurement, x_i becomes available, where $i = 1,2,3,\ldots$ and $S_0 = 0$

7. Compute the Shewhart and CUSUM tests as each new monitoring measurement becomes available; a verification sampling will be conducted if either $x_i \geq$ SCL or $S_i \geq$ CCL. A well is declared to be out of control only if the verification result also exceeds the SCL or the CCL. If both $x_i <$ SCL and $S_i <$ CCL, then continue monitoring.

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8. Update the baseline mean and standard deviation periodically (every year or two) to incorporate new data as monitoring continues and the process is shown to be in control. This updating process should continue for the life of the monitoring program.

If resampling is implemented during the monitoring, the analytical result from the resample is substituted into the above formulas for the original value obtained, and the CUSUM statistic is updated. Note in the above combined test that the Shewhart portion of the test will quickly detect extremely large deviations from the baseline period. The CUSUM portion of the combined test is sequential; thus, a small shift in the mean concentration over the baseline period will slowly aggregate in the CUSUM statistic and eventually cause the test to exceed the CUSUM control limit CCL.

7.3.4 Detection Status

In order to arrive at appropriate control limits, the detection history for each constituent of concern at each well must first be evaluated. Historical measurements subsequent to January 1995 were judged to be most relevant for data evaluation purposes because in December 1994 the trenches were administratively isolated and all discharges were terminated and complete physical isolation occurred in January 1995. Detection status of constituents of concern using data obtained from February 1995 through March 2001 is presented in Table 7.1.

7.3.5 Baseline Summary Statistics and Control Limits

The 300 Area process trenches were operated to receive effluent discharges containing dangerous waste from nuclear research and fuel fabrication laboratories in the 300 Area between 1975 and 1994. Uranium was one of the contaminants of concern. In July 1991, the trenches were modified as part of an expedited response action that involved removing bottom sediment from the inflow end of the trench and placing it at the opposite end of the trench behind a berm. In December 1994, the trenches were administratively isolated and all discharges were terminated. Complete physical isolation occurred in January 1995. In addition, the first proposal to change from a compliance monitoring plan to a corrective action plan was initiated in June 1997 when results from the first four independent samples confirmed the exceedance of maximum contaminant levels for cis-DCE, TCE, and uranium (see Section 1.2). The proposed baseline period (from February 1995 to July 1997) and sampling and statistical methods are adopted in Ecology letter[6] except for special conditions noted at the site. These special conditions included

1. Uranium in well 399-1-17A – This is a case where a steady process mean and less variability are noted subsequent to original baseline period, February 1995 – July 1997 (see concentration versus time plot in Appendix B). Use of data obtained from August 1998 – August 2000 as the revised baseline period results in a lower and tighter control limits.

[6] Letter from Dib Goswami (Washington State Department of Ecology, Olympia, Washington) to Marvin Furman (U.S. Department of Energy, Richland, Washington), *Statistical Assessment for the 300 Area Resource Conservation and Recovery Act of 1976 (RCRA) Ground Water Monitoring Plan*, dated May 7, 2001 (see Appendix D).

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Table 7.1. Detection Status of Contaminants of Concern Analyzed for the 300 Area Process Trenches (February 1995 through March 2001)

Contaminant of Concern	Total Number of Observations	Number of Detects	Number of Non-Detects	Detect Frequency[a] (%)	Maximum Detected Value (µg/L)
Well 399-1-16A					
cis-DCE	38	14	24	37	0.7
TCE	38	30	8	79	1
Uranium	39	39	0	100	165
Well 399-1-16B					
cis-DCE	38[b]	38	0	100	190
TCE	39[b]	35	4	90	10
Uranium	37	37	0	100	14.8
Well 399-1-17A					
cis-DCE	42	6	36	14	5
TCE	41	29	12	71	2
Uranium	43	43	0	100	313
Well 399-1-17B					
cis-DCE	38	38	0	100	4.7
TCE	38	1	37	3	0.03
Uranium	38	15	23	39	0.70
Well 399-1-10A					
cis-DCE	38	2	36	5	0.43
TCE	38	5	33	13	0.3
Uranium	39	39	0	100	144
Well 399-1-10B					
cis-DCE	35	1	34	3	0.25
TCE	35	0	35	0	ND
Uranium	33[b]	20	13	61	0.392

(a) Obtained by using the number of detected observations divided by the number of total observations.
(b) Outlier removed.
ND = Not detected.

2. TCE in well 399-1-16B – This is a case where a downward trend is observed subsequent to the original baseline period, February 1995 – June 1997 (see concentration versus time plot in Appendix B). Use of the maximum contaminant level (5 micrograms per liter) as the control limit is more protective of human health and the environment.

Table 7.2 provides respective baseline periods and the summary statistics for the contaminants of concern analyzed from samples from the wells monitoring the 300 Area process trenches where sufficient data exist. The baseline periods originally proposed to Ecology in 1997 were kept intact unless current site conditions warrant a revision (e.g., uranium in wells 399-1-16B and 399-1-10A, cis-DCE in well 399-1-17B).

Table 7.2. Baseline Summary Statistics for Contaminants of Concern Analyzed for the 300 Area Process Trenches

Contaminant	Baseline Period	Baseline Observation	Detected	Non-Detect	Detect %	√ (μg/L)	s (μg/L)
Well 399-1-16A							
cis-DCE	3/29/95 - 6/19/97	9	3	6	33	0.213	0.131
TCE	3/29/95 – 6/19/97	9	9	0	100	0.641	0.242
Uranium	3/29/95 – 6/19/97	9	9	0	100	97.55	38.33
Well 399-1-16B							
cis-DCE	3/29/95 – 6/19/97	9	9	0	100	150.8	24.8
TCE[a]	3/29/95 – 6/19/97	9	8	1	89	3.907	2.949
Uranium	8/17/98 –8/01/00[b]	16	16	0	100	12.02	1.94
Well 399-1-17A							
cis-DCE	2/21/95 – 6/19/97	14	2	12	14	NC	NC
TCE	2/21/95 – 6/19/97	13	10	3	77	0.346	0.255
Uranium[a]	8/17/98 –8/01/00[b]	16	16	0	100	112.3	26.40
Well 399-1-17B							
cis-DCE	8/17/98 –8/01/00[b]	16	16	0	100	2.888	0.969
TCE	3/27/95 – 7/18/97	10	1	9	10	NC	NC
Uranium	3/27/95 – 7/18/97	10	7	3	70	0.059	0.136
Well 399-1-10A							
cis-DCE	3/27/95 – 6/19/97	9	1	8	11	NC	NC
TCE	3/27/95 – 6/19/97	9	2	7	22	NC	NC
Uranium	8/17/98 – 8/8/00[b]	15	15	0	100	53.067	11.858
Well 399-1-10B							
cis-DCE	3/27/95 – 9/9/97	9	0	9	0	NC	NC
TCE	3/27/95 – 9/9/97	9	0	9	0	NC	NC
Uranium	3/27/95 – 12/9/97	8	8	0	100	0.097	0.104

(a) Special conditions adopted by Ecology (Letter from Dib Goswami [Washington State Department of Ecology, Olympia, Washington] to Marvin Furman [U.S. Department of Energy, Richland, Washington], *Statistical Assessment for the 300 Area Resource Conservation and Recovery Act of 1976 (RCRA) Ground Water Monitoring Plan*, dated May 7, 2001 [see Appendix D].)
(b) Revised baseline period (more representative of current site conditions).
NC = Not calculated.

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A summary of various control limits for the 300 Area process trenches is presented in Table 7.3. It should be noted that one of the contaminants of concern, uranium, has a natural background resulting from water-rock reaction during evolution of the ambient groundwater. This natural background forms a permanent baseline above which changes due to addition from the regulated unit will be detected. Therefore, when the calculated control limits (SCL and CCL) are less than the natural background for uranium, the control limits should be set at the natural background 12.8 μg/L that is the maximum observed background value for the Hanford Site (see Table ES-1, DOE 1997b). This is consistent with ASTM guidance (1996) in using the nonparametric prediction limit (which is the maximum observed value) as the control limit. For contaminants other than uranium where detection frequency is less than 25% (i.e., cis-DCE in wells 399-1-17A, 399-1-10A, and 399-1-10B and TCE in wells 399-1-17B, 399-1-10A, and 399-1-10B), most recently determined quantitation limit (e.g., Hartman et al. 2001, Table B.20) will be used as control limits.

Special procedures to be used as specified by Ecology[7] are as follows:

1. For wells where the maximum contaminant level has been and still is exceeded, quarterly monitoring will be conducted. One sample will be collected from each well during each sampling event and compared to the agreed upon control limits (see Table 7.3) for each identified constituent of concern (i.e., cis-DCE, TCE, and uranium). If a control limit is exceeded (proof by verification sampling), a notification process will be followed.

2. For wells where the maximum contaminant level has not been exceeded, semiannual monitoring will be conducted. One sample will be collected from each well during each sampling event and compared to the agreed upon control limits (see Table 7.3) for each identified constituent of concern (i.e., cis-DCE, TCE, and uranium). A notification process will be followed after a confirmed exceedance (by verification sampling).

3. Currently, tetrachloroethene (PCE) is not detected in the wells monitoring the 300 Area process trenches. However, it has been detected in the past. PNNL will continue to monitor PCE and report detected results.

The proposed statistical approach shall be in effect for a period of two years. Based on the results of this evaluation period, Ecology will decide whether to continue, modify, or abandon the proposed approach at the 300 Area process trenches.

7.4 Reporting

Chemistry and water-level data are reviewed at least quarterly and are available in HEIS.

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[7] Letter from Dib Goswami (Washington State Department of Ecology, Olympia, Washington) to Marvin Furman (U.S. Department of Energy, Richland, Washington), *Statistical Assessment for the 300 Area Resource Conservation and Recovery Act of 1976 (RCRA) Ground Water Monitoring Plan*, dated May 7, 2001 (see Appendix D).

Table 7.3. Summary of Various Control Limits at the 300 Area Process Trenches

Contaminant of Concern	Shewhart-CUSUM Parameter Value	Control Limit[(a)] (µg/L)
Well 399-1-16A		
cis-DCE	4.5	0.803
TCE	4.5	1.72
Uranium	4.5	270
Well 399-1-16B		
cis-DCE	4.5	[39, 262][(c)]
TCE	NA	5[(d)]
Uranium	4[(b)]	[4.3, 19.8]
Well 399-1-17A		
cis-DCE	NA	0.81[(e)]
TCE	4[(b)]	1.36
Uranium	4[(b)]	[7, 218]
Well 399-1-17B		
cis-DCE	4[(b)]	6.77
TCE	NA	0.72[(e)]
Uranium	NA	12.8[(f)]
Well 399-1-10A		
cis-DCE	NA	0.81[(e)]
TCE	NA	0.72[(e)]
Uranium	4[(b)]	[6, 101]
Well 399-1-10B		
cis-DCE	NA	0.81[(e)]
TCE	NA	0.72[(e)]
Uranium	NA	12.8[(f)]

(a) Obtained by using applicable Shewhart-CUSUM parameter value times the baseline standard deviation (see Table 7.2) and adding the product to the baseline mean (see Table 7.2).
(b) Use 4 sigma because there are more than 12 data points in the baseline period (ASTM 1996).
(c) Numbers in brackets indicate upper and lower limits.
(d) Use maximum contaminant level MCL (5 µg/L) as the control limit because of the downward trend noted in this well subsequent to the baseline period.
(e) Use most recently determined quantification limit (see Table B.20, Hartman et al. 2001, Appendix B) because analyte detection frequency is less than 25% (ASTM 1996).
(f) Use maximum observed uranium background value (see Table ES-1, DOE 1997b) as the control limit because calculated control limit is less than the natural background level at the Hanford Site.

Semiannual reports on the current status of groundwater under corrective action are supplied to the regulator as required by sites in RCRA final status.

Results and interpretations of groundwater monitoring data will be reported in the annual groundwater monitoring report of the Hanford Site Groundwater Monitoring Project (e.g., Hartman et al. 2001).

When a statistical control limit has been exceeded and verification sampling has confirmed the exceedance, the regulator will be notified of the exceedance by phone and, if follow-up action is required, the phone call and action required will be confirmed by written notification. PNNL will keep a phone log.

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